IMPROVEMENT OF EMISSIONS INVENTORIES FOR INDUSTRIAL COATINGS AND THINNING AND CLEANUP SOLVENTS

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The survey of manufacturers of coatings for original equipment manufacturing was conducted by Tetra Tech, Inc. (Eddy Huang, Subcontract Manager). The evaluation of spatial surrogates was conducted by Chambers Group, Inc. (Larry Freeberg, Subcontract Manager).

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ABSTRACT

Much of the current emission inventory for industrial coatings and associated thinners and cleanup solvents, as well as for thinners and cleanup solvents associated with architectural and industrial maintenance (AIM) coatings, is outdated or based upon undocumented assumptions. To improve the inventory, we surveyed industrial coating manufacturers, users of industrial coatings, commercial painters and homeowners who did their own house painting. From the survey findings, we developed new emission factors and speciation profiles, and established several new factors for relating solvent use to coating use. Using our results in conjunction with the ARB's 2001 architectural coatings survey, we developed estimates of solvent use by county and air basin, and total organic gas (TOG) and reactive organic gas (ROG) emissions by county, air basin, and air pollution control district. Our thinning and cleanup solvent emissions estimates are higher than stated in the current inventory for architectural and industrial maintenance coating use. We developed growth factors to project architectural coating and solvent emissions. Finally, we identified data sources, software, and an algorithm for allocating county AIM coatings to grid squares, using census block population and numbers of owner-occupied households as surrogate variables.

EXECUTIVE SUMMARY

BACKGROUND

The California Air Resources Board (ARB) has determined that an important source of emissions of total organic gases (TOG) and reactive organic gases (ROG) in the State may be evaporation of solvents from original equipment manufacturing (OEM) coatings; the thinners and cleanup solvents associated with OEM coatings; and thinners and cleanup solvents associated with architectural and industrial maintenance (AIM) coatings. The ARB's 2002 Statewide Emission Inventory includes 161 tons/day of TOG and 150 tons/day of ROG from these sources. Much of the current inventory for industrial coatings and associated solvents is based upon information from surveys conducted more than 20 years ago. This information needed to be updated. In addition, the current estimate of thinning and cleanup solvents associated with AIM coatings is based upon the assumption that one pint of solvent is used per gallon of solvent-based coating. The validity of that assumption needed to be examined. Furthermore, information on the distribution of solvent use activity by hour of day, day of week and by month of year was needed for modeling purposes. Finally, ARB staff wished to know how extremes of weather affect use of coatings and associated solvents.

METHODS

Information on coating and solvent use was gathered through mail and/or telephone surveys of OEM coating manufacturers, users of OEM coatings, commercial painting contractors, and homeowners. Over 750 OEM coating manufacturers were asked (by written questionnaires and follow-up telephone calls) to report the volumes of OEM coatings that they sell to California distributors and/or end users, and to provide detailed information on the chemical compositions and physical properties of the coatings.

The OEM coating users, which comprised a random sample of about 5,000 manufacturing plants, were asked (by written questionnaire) to report their solvent- and water-based coating use; the names and quantities of thinning and cleanup solvents; information about the distribution of their painting activity by hour of day, day of week and month of year; and whether and how they would change their use of solvents in unusually hot, cold, or inclement weather.

The survey of commercial painters, which included a random sample of 2,055 painting contractors in the State, was similar to that for the OEM coating users. Although written questionnaires were sent, a large portion of the information in this survey was obtained by telephone. For the OEM coating users and commercial painters surveys, we collected material safety data sheets (MSDSs) for the solvents identified by survey respondents, and stored information on solvent density and chemical composition.

Finally, we telephoned about 2,500 randomly selected homeowners and asked them about the frequency of their house painting; the types and quantities of solvent materials they use; whether they paint on weekdays, weekends, or both; their relative painting activity

by time of day and season of year; and how they would change their painting behavior in response to unusually hot, cold or inclement weather.

In parallel with the surveys, we investigated methods of projecting material use and emissions estimates to future years. We also explored options for allocating county-level emissions to sub-county geographical areas, including 2 kilometer by 2 kilometer grid cells.

RESULTS

The survey of OEM coating manufacturers proved to be inadequate for estimating the volume of OEM coatings used in California. Using an approach based on apportioning national coating sales to California, we estimate this value to be between 34.2 and 42.7 million gallons per year (gpy). The survey data were adequate for developing new emission factors for solvent- and water-based can and coil, metal parts and products, wood furniture and fixtures and other coatings; solvent-based marine coatings; and water-based metal furniture coatings. This will improve estimation of emissions from industries that use these coatings. We also had enough data to estimate statewide uncontrolled TOG and ROG emissions from use of only three types of OEM coatings: wood furniture and fixtures, can and coil, and metal furniture; these total 52.7 tons per day (tpd) of TOG and 37.7 tpd of ROG. From our commercial painters survey, we could neither verify nor invalidate the assumption of one pint of solvent per gallon of solvent-based coating. However, we did derive three new use ratios: 8.85 ounces (oz) of thinner per gallon of solvent-based coating; 3.15 oz of cleanup solvent per gallon of solvent- and water-based coating combined; and 0.78 oz of additive per gallon of water-based coating. We also developed new emission factors for several solvent categories and speciation profiles for OEM coatings and various solvent formulations. Combining the results of our surveys with those of the ARB's 2001 survey of AIM coatings, we estimate that commercial painters and homeowners use 3,140,000 and 126,000 gpy of solvents, respectively. Statewide emissions of TOG and ROG from evaporation of thinning and cleanup solvents and additives for AIM coatings are 26.6 and 24.1 tpd, respectively. We developed growth factors, based upon Employment Development Department occupational survey data, for use and emissions from solvents associated with AIM coatings. Finally, we identified data sources, software and an algorithm for allocating county AIM emissions to grid squares, using census block population as a surrogate variable.

CONCLUSIONS

A survey of OEM coating manufacturers to estimate statewide OEM coating use is not likely to be fruitful, unless it is mandatory. We recommend using data from annual emissions reporting data maintained by the large districts (e.g. South Coast Air Quality Management District), supplemented by highly focused surveys of OEM coating users. Our statewide estimates of TOG and ROG emissions from AIM coating use are about 45 and 35 percent higher, respectively, than the estimates in the ARB's 2003 emission inventory. The use factors and the emission factors and speciation profiles for OEM coatings and for solvents associated with AIM coatings will prove useful in updating and constructing emission inventories.

1.0
INTRODUCTION

1.1 BACKGROUND

The California Air Resources Board (ARB) has determined that an important source of emissions of total organic gases (TOG) and reactive organic gases (ROG) in the State may be evaporation of solvents from original equipment manufacturing (OEM) coatings; the thinners and cleanup solvents associated with OEM coatings; and thinners and cleanup solvents associated with architectural and industrial maintenance (AIM) coatings. The ARB's 2002 Statewide Emission Inventory includes 161 tons/day of TOG and 150 tons/day of ROG from these sources. Much of the current inventory for industrial coatings and associated solvents is based upon information from surveys conducted more than 20 years ago. This information needed to be updated. In addition, the current estimate of thinning and cleanup solvents associated with AIM coatings is based upon the assumption that one pint of solvent is used per gallon of solvent-based coating. The validity of that assumption needed to be examined. Furthermore, information on the distribution of solvent use activity by hour of day, day of week and by month of year was needed for modeling purposes. Finally, ARB staff wished to know how extremes of weather affect use of coatings and associated solvents.

1.2 A NOTE ON TERMINOLOGY

In an attempt to be unambiguous, we have used the term original equipment manufacturing (OEM) coatings instead of "industrial coatings." The problem with the latter is that may be confused with "industrial maintenance (IM) coatings," which are usually considered in connection with architectural coatings. OEM coatings are those used on products when they are first manufactured. They do not include coatings used for equipment maintenance or repair. We have stretched the definition of original equipment manufacture a bit, to include cases where one firm manufactures a product and then has another firm apply a coating.

1.3 A NOTE ON THE CONTRACTOR

As several contractor names are mentioned in this report, some explanation is in order. The contract was originally signed between the ARB and Pacific Environmental Services, Inc. (PES). PES, in turn, had subcontracts with ATC Associates, Inc. (ATC) and Chambers Group, Inc. (CGI). In 2001, PES became a subsidiary of MACTEC, Inc., while retaining its name. In late 2001, the PES individuals working on this contract were transferred to Harding ESE, Inc., another MACTEC subsidiary, and the contract was amended to show Harding ESE, Inc. as the contractor. Then, in 2002, Harding ESE, Inc. and portions of other MACTEC subsidiaries became MACTEC Engineering and Consulting, Inc., and the contract was amended to show the name change. As there have been no other changes since then, the contract of record for this project is MACTEC Engineering and Consulting, Inc., which will be referred to as "MACTEC." However, in discussing

the history of the surveys we conducted, we will use whatever name was valid at the point of discussion.

In the mean time, Dr. Eddy Huang, who headed ATC's subcontract on this project, moved to Tetra Tech, Inc. (Tetra Tech) in April, 2001. A new subcontract was then negotiated with Tetra Tech.

1.4 PROJECT OBJECTIVES

The objectives of this study were to:

(1) Determine the amounts of original equipment manufacturing (OEM) coatings, thinning solvents and cleanup solvents associated with OEM coatings, used in California, by county, during 2001;

(2) Determine the amounts of thinning solvents and cleanup solvents associated with architectural and industrial maintenance (AIM) coatings, used in California, by county, during 2001;

(3) Verify, or obtain a new value for, the ARB's assumption that one pint of thinning and cleanup solvents are used per gallon of AIM coating;

(4) Develop composite emission factors and speciation profiles for various categories of materials;

(5) Develop temporal profiles for the use of OEM coatings, thinning solvents and cleanup solvents;

(6) Construct 2001 emission inventories for the state, counties, air basins, and air pollution control districts for OEM coatings, thinning solvents and cleanup solvents;

(7) Obtain data on the influence of ambient temperature and precipitation on the pattern of coatings and solvents application;

(8) Develop spatial surrogates for the areas of the State where most emissions from these materials are likely to occur; and

(9) Specify sources of information for annual updates for activity factors

1.5 OVERVIEW OF THE RESEARCH

To accomplish the project's objectives, we conducted separate surveys of OEM coating manufacturers, OEM coating users, commercial painters, and homeowners. For each survey, we obtained a mailing list, designed questionnaires and telephone scripts, conducted a "pilot survey" to test survey instruments and methods, and then conducted a full survey. A Microsoft® Access database was used to track survey responses, store reported

data, and extract information for calculations. In addition, we explored data sources and techniques for allocating county-level data to smaller geographic units, including 2 km x 2 km grid squares. Finally, we obtained information for forecasting survey results to future years.

1.6 OUTLINE OF THE REPORT

Chapter 2 describes in detail our methods for conducting the surveys, analyzing the results, and estimating emissions. Chapters 3 through 6 are each devoted to one of the surveys. They provide detailed survey results and report our estimates of volumes of coatings and solvents used statewide, by county, and by air basin. Chapter 7 presents the coating and solvent emission factors that we developed from the survey data. Emission inventory results are reported in Chapter 8. New species profiles for coatings and solvents are provided in Chapter 9. In Chapter 10, we present a plan for using surrogate variables to allocate emissions from counties to smaller geographical areas, including 2 km x 2 km grid cells. Chapter 11 contains a method for forecasting architectural coating emissions up to 2010. A discussion of some survey issues may be found in Chapter 12. Chapter 13 contains a summary of the most important findings of all the previous chapters. Some recommendations for future research are in Chapter 14. Finally, references cited are listed in Chapter 15.

2.0

MATERIALS AND METHODS

2.1 OEM COATINGS MANUFACTURERS RESEARCH

2.1.1 Objectives

The objective of this research was to obtain, through a survey, the following information from manufacturing facilities that sell OEM coatings and associated solvents to California:

- Quantities and types of OEM coatings sold to California;
- Recommended ratio of thinners and cleanup solvents associated with OEM coatings;
- Data on composition of OEM coatings;
- Actual VOC and regulatory VOC content of OEM coatings used in California; and
- Speciation of OEM coatings.

2.1.2 Pre-Survey Investigations

As part of the design process for the surveys to be conducted for this project, the MACTEC team visited four coating manufacturers and interviewed knowledgeable staff. The visits had three main purposes:

- To learn more about aspects of the industry relevant to this project;
- To determine the availability of the types of data that we would be requesting in the survey; and
- To obtain feedback on preliminary designs of survey instruments

The following are summaries of the visits and the most useful information obtained.

Company A is a nationwide manufacturer of OEM coatings, with headquarters in California. It produces and sells more than 100 types of coatings. On the visit, we learned that it would be prohibitively difficult and expensive for even technically advanced companies such as this one to obtain and provide detailed speciation data beyond what is reported on material safety data sheets (MSDSs). We also learned that shipping addresses are frequently not correlated with points of use; coatings sold to a California distributor may be immediately re-shipped to other states or Mexico. Finally, this company suggested that survey form instruc-

tions be on the same pages (or on the back sides) as the areas where data are requested.

Company B's main products are printing inks and adhesives, but it does produce some specialty coatings for OEM use. Its OEM coatings sales are always directly to the users. The company's representative pointed out that, since its OEM coatings are custom-designed for its clients, it would have to search through hundreds or thousands of individual orders to obtain the type of information that we would seek. One solution might be to report ranges of composition.

Company C is a major coatings manufacturer, but it was determined on the site visit that it does not produce OEM coatings.

On our visit to **Company D**, we went over a draft of the questionnaire forms with a plant representative. It was suggested that we expand the list of coating categories.

2.1.3 Sampling Frame and Selection of the Survey Sample

The sampling frame for this survey was all manufacturing facilities that were likely to sell significant quantities of OEM coatings and associated thinners and cleanup solvents to California.

2.1.3.1 Definition of the Sampling Frame

Using our general knowledge of OEM coatings, we identified twelve six-digit standard industrial classification (SIC) codes likely to be associated with OEM coatings, thinners and solvent manufacturing. A comprehensive list of industrial coatings manufacturers was assembled and purchased from InfoUSA.com (InfoUSA), a mailing list provider. According to InfoUSA, there are potentially 729 OEM coating manufacturers in those SIC codes.

2.1.3.2 Initial Selection of the Sample

From the U.S. Census Bureau and other government agencies, statistics on sales of industrial coatings were gathered as general background information for the survey. The list from the InfoUSA database, incorporated with other industrial coatings manufacturers identified earlier by the team was the backbone of the final mailing list for survey.

2.1.4 Pilot Survey

Between April 22 and May 31, 2002, a pilot survey of OEM coatings manufacturers was conducted. The objectives of the survey were to identify areas where the survey instruments and methods could be improved and to obtain initial estimates of some of the survey variables.

2.1.4.1 Pilot Survey Methods and Response

A pilot survey questionnaire was designed and approved by ARB staff after review. We selected 25 OEM coatings manufacturers as well as manufacturers of thinners and cleanup solvents associated with OEM coatings for the pilot survey. On April 25, 2002, each company was mailed an envelope containing a cover letter, a seven-page questionnaire, and an explanatory letter from the ARB. The questionnaire included a form for the respondent to provide comments and suggestions. A Microsoft Access™ database generated mailing labels, kept track of the response status of each facility, and recorded data provided on the responses.

Table 2-1 characterizes the responses to the pilot survey. Data useful for the survey were obtained from three facilities. By the end of May 2002, the team had attempted to call all 25 companies in the pilot survey. A second copy of the survey package was faxed to three firms, and re-mailed to another two. The three useful responses comprise 12 percent of the original potential sample.

Table 2-1

RESPONSE TO THE PILOT SURVEY OF OEM COATING MANUFACTURERS

TOTAL SURVEY PACKAGES MAILED			25
Ineligible for the Survey			20
	Not an OEM manufacturer	9	
	Administrative/Sales Office Only	1	
	No California Sales	10	
ADJUSTED POTENTIAL SAMPLE			5
	Explicitly Refused to Respond	2	
	Responded With Data	3	

2.1.4.2 Implications of Findings for the Main Survey

After the pilot survey was completed, we held several discussions with the ARB about changing the scope of the survey of OEM coatings manufacturers. It was decided to expand the survey to ask respondents to report types of coatings (marine, paper, fabric, metal furniture and fixture, can and coil, metal parts and products, wood furniture and fixture, pleasure craft, and other), and bases of coatings (solvent-based, or water based). The manufacturer's recommended ratios for thinning solvents were deleted from the main survey. Changes to the survey materials and procedures were as follows.

Changes to Survey Forms

Given the aforementioned change in scope, it was necessary to redesign the questionnaire substantially. The following were the major changes:

- Form 1 (Facility Information) was revised: it no longer asked the manufacturers to report whether they produced/blended OEM coatings, or operated in 2001;

- Form 2 (Product Information) was revised: it no longer asked the manufacturers to report recommended amounts of thinners associated with each of nine coating types;[1]

- Form 4 (Survey Recipient Feedback) was deleted; and

- An updated letter from the ARB Project Manager was customized for this survey.

Changes to Survey Procedures

- If the presumed contact at a given manufacturer was not available, we asked for a "environmental engineer" or "operations manager;" we did not leave detailed messages for presumed contacts at each facility;

- We limited our follow-up calls to five; and

- We resent the survey packages by fax.

2.1.5 Instruments for the Main Survey of OEM Coating Manufacturers

Every manufacturer in the potential sample was mailed a survey "package" containing the following:

- A cover letter from Tetra Tech, Inc.;
- A three-form questionnaire; and
- A letter from the ARB.

Examples of the letters and forms are in Appendix A. The cover letter and forms were printed on 11-inch x 17-inch stock and folded into a "booklet;" Forms 2 and 3 were printed on 8.5-inch x 11-inch stock and inserted into the booklet. The cover letter introduced the survey, stated its purpose, promised that information provided would be published in summary form only and would not be associated with any particular manufacturer, and briefly described the forms. Form 1 asked for basic facility information (address, contact person, etc.), and asked for the URL address to download MSDSs. Form 2 asked the respondent to report the product names, densities, actual VOCs, regulatory VOCs, and volumes of all OEM coatings sales to California destination. We divided the OEM coatings into the following general types:

[1] It is a common practice for OEM coating users to use the amount of thinning solvent required by a particular application, permit conditions, and other local factors, rather than to rely solely on the coating manufacturer's recommendation.

- Marine
- Paper
- Fabric
- Metal Furniture and Fixture
- Can and Coil
- Metal Parts and Products (except furniture)
- Wood furniture and Fixture
- Pleasure Craft
- Other

Form 2 also included instructions for calculating actual VOC (material VOC) and regulatory VOC (coating VOC).

Form 3 requested information on individual component (VOCs and exempt compounds, CAS numbers, and weight percents). The survey included aggregated VOCs and exempt compounds less than 0.1 weight percent, weight percent of water, and weight percent of solids (total of all ingredients must equal 100 percent).

2.1.6 Survey Database Management System

For this survey, we created a relational database in Microsoft® Access™ and used it to track the status of surveys and record survey responses. The main tables and their purposes were:

- FACILITIES – Manufacturers' names, addresses, contacts, telephone numbers

- MSDS DATA – Names, types, sales, and material and regulatory VOC content of reported coatings

- MSDS SPECIES – CAS numbers and weight percentages of all reported ingredients

- STATUS – Dates of various milestones (mail out, follow-up calls, etc.) in the survey of each facility, along with comments from survey staff

The tables were linked by various key fields. For example, each coating product had a unique identification number (PID) in the MSDS DATA table. The same PID value was used for every chemical species record for that coating in MSDS SPECIES, so that one could (1) search for all the ingredients in a given coating or (2) identify all coatings having a given ingredient. Meanwhile the PIDs were linked to unique identifiers for the manufacturers (OEMID), so that one could know the manufacturer of a given coating. The database contained many frequently used and *ad hoc* queries and forms entering and updating information and for extracting and reporting data.

2.1.7 Follow-Up Activities

Tetra Tech attempted to contact all coating manufacturers in the survey by telephone, to encourage a response. Second copies of the forms were mailed to 20 firms and faxed to 46. Despite this effort, only 18 responses with useful data were received by the end of October, 2002. The responding firms produced 147 different coatings and sold about 1.6 million gallons to California, far below the amount estimated by other means. (See Section 3.1.). The main survey had reached an impasse. Two major OEM coatings manufacturers indicated that they could respond, but they would need from two to six months to prepare their submittals. Most of the other manufacturers had either not responded at all, or had stated that they did not have the resources to devote to the time-consuming data compilation that was required. It was clear that significant further progress in this survey was unlikely.

To overcome some of the problems with the main survey, some changes to the original approach were necessary. The revised approach comprised three steps:

(1) A survey of known users of OEM coatings to identify the manufacturers and distributors of the coatings that they use;

(2) Review of survey results and identification of the most "important" makes and models of OEM coatings; and

(3) A "prioritized survey" of only the manufacturers and distributors of the most "important" coatings, to obtain California sales data and detailed product information only for those coatings.

2.1.7.1 Survey of Known OEM Coating Users

The purpose of this step was to identify specific makes and models of OEM coatings that were used in California. To ensure that the survey recipients were all OEM coating users, facilities that were subject to eleven coating-specific rules of the South Coast Air Quality Management District (SCAQMD)[2] were surveyed. These rules are listed in Table 2-2. From the SCAQMD's Public Records Unit, a data file for each rule was obtained. The file contained the names and addresses of the facilities and total volatile organic compound (VOC) emissions for each facility.

The facility data were entered into a Microsoft Access database similar to the one described above. Many facilities were subject to more than one coating rule, and therefore appeared on more than one list. However, as each facility had a unique SCAQMD identification number, all of the records for a given facility were consolidated into one record, flagging all its applicable rule numbers. Using the VOC emissions values provided by the District, the facilities for each rule were ranked in decreasing order of emissions. Finally, those facilities, in each rule group, accounting for 75 percent of annual VOC emissions were selected.

[2] We did not include Rule 1151 (Motor Vehicle and Mobile Equipment Non-Assembly Line Coating Operation), because the ARB was currently conducting a survey of manufacturers of these types of coatings.

Table 2-2

SCAQMD RULES GOVERNING OEM COATINGS

Rule	Coating Category
1104	Wood Flat Stock Coating Operations
1106	Marine Coating Operations
1106.1	Pleasure Craft Coating Operations
1107	Coating of Metal Parts and Products
1115	Motor Vehicle Assembly Line Coating Operations
1124	Aerospace Assembly and Component Manufacturing Operations
1125	Metal Container, Closure, and Coil Coating Operations
1126	Magnet Wire Coating Operations
1128	Paper, Fabric, and Film Coating Operations
1136	Wood Products Coatings
1145	Plastic, Rubber, and Glass Coatings

This special scoping survey identified 24 OEM coating manufacturers that sold their products to California; the firms accounted for 46 coating products. The results of the survey of users were reviewed to identify the most frequently cited and/or the highest-volume coatings in each rule category. The rationale was that the manufacturers that were surveyed in the next step would be more amenable to a request for data on two or three of their products than they would be to report on all their products.

2.1.7.2 Prioritized Survey of OEM Coatings Manufacturers

The last step was to send a revised version of the main survey package to the OEM coatings manufacturers chosen in the previous step. The cover letters were customized to each manufacturer. For Form 1, the list of coating types was deleted and stated that only up to three specific products would be reported. For Form 2, the main table was replaced with a set of check boxes, so that the respondent could confirm the coating product type easily. A draft of the revised survey package was sent to the ARB and to the National Paint and Coatings Association for review.

The main advantage of this approach was that the manufacturers contacted (or re-contacted, if they were in our original survey) might be more willing to provide data. Another advantage was the OEM coatings manufacturers were put on notice in the cover letter that records indicated they sold coatings to California end users. As a result, they could not claim that they did not manufacture OEM coatings or that they had no California customers.

A noticeable disadvantage was that, by concentrating on the "most important" individual coatings, other coatings that might be significant in combination could be ignored. An-

other potential problem was that a coating identified by an OEM coating user in Step 1 could be very important for that firm but might be a custom product that the coating manufacturer did not sell to anyone else. Having only one client for its product, the coating manufacturer most likely would not divulge its sales.

The prioritized survey was conducted in October, 2003. All companies on the prioritized list were contacted at least four times.[3] As will be discussed in Section 3.2, the new survey yielded six additional responses.

2.1.8 Survey Data Processing and Calculations

Data from the survey forms were entered into the above-described Access database as they were received. Various queries were used to extract data and export them to Excel workbooks for calculations. Calculation of weighted average TOG, ROG and regulatory VOC values and of speciation profiles is discussed in Section 2.6.

2.1.9 Survey Quality Assurance/Quality Control

In general, we followed the quality assurance plan that was prepared for this project (PES, 2002). All survey response data were reviewed by the Tetra Tech survey manager for completeness and consistency. A particular problem with this survey was that several OEM coating manufacturers merged and/or changed names; the result was duplicate reporting of some information. All double counting was identified and eliminated.

All of Tetra Tech's TOG and speciation calculations were reviewed by the Principal Investigator to verify that spreadsheet formulas were correct and that the results were reasonable. Corrective measures were then reviewed by the Tetra Tech survey manager.

2.2 OEM COATINGS USERS SURVEY

2.2.1 Objective

The objective of this survey was to obtain the following information from manufacturing facilities that apply OEM coatings to the products that they manufacture:

- Quantities and types of thinners and cleanup solvents associated with OEM coatings;
- Data on composition of thinners and cleanup solvents;
- Temporal patterns of coating and thinner and cleanup solvent use; and
- Effect of weather on use of thinners and cleanup solvents for OEM coatings

[3] Tetra Tech continued trying to reach the 347 firms that had not responded to the main survey, but none of these submitted a response.

2.2.2 Sampling Frame and Selection of the Survey Sample

The sampling frame for this survey was all manufacturing facilities in California that were likely to use significant quantities of OEM coatings and associated thinners and cleanup solvents.

2.2.2.1 Initial Definition of the Sampling Frame

Using our general knowledge of industrial processes, we identified 136 four-digit standard industrial classification (SIC) codes where OEM coatings potentially would be used. Our mailing list provider, InfoUSA.com, determined that there are 30,614 facilities in California in those SIC codes (Walker, 2001).[4] It had been the principal investigator's experience in recent surveys that a significant number of SIC codes believed *a priori* to be relevant turned out not to be. To avoid wasting resources on ineligible facilities, we conducted a "pre-pilot" survey to identify SIC codes among the 136 that were <u>not</u> likely to have significant OEM coating use.[5]

2.2.2.2 Pre-Pilot Survey

The first step was to identify those SIC codes (of the original 136) for which there was substantial evidence that OEM coatings are applied. We reviewed a permit database provided by the San Joaquin Valley Unified Air Pollution Control District for a recent project (Rogozen, 2000a, 2000b). SIC codes for which at least one piece of permitted coating equipment (e.g. a spray booth) was listed were assumed to be valid. In addition, ARB staff searched the California Emissions Inventory Development and Reporting System (CEIDARS II) database for facility- or process-level SICs for which the source classification code (SCC) contained "coatings" in its definition (Look, 2001). Between the two searches, we verified that OEM coatings were used in 105 of the 136 SIC codes.

The purpose of the "pre-pilot" survey was to determine, relatively quickly and inexpensively, if facilities in the 31 remaining questionable four-digit SIC codes were likely to use OEM coatings. Up to ten[6] facilities in each SIC code were selected at random from the Power Business™ database, Version 1.3 (InfoUSA, Papillon, NE) which was obtained on CD ROM. In each case, we verified through the database that the SIC codes for the selected firms were *primary* SIC codes, not secondary ones.

The survey was conducted entirely by telephone, between June 20 and July 3, 2001. The telephone script for the pre-pilot survey is in Appendix A. In a few cases, facilities asked for verification that we were under contract to the ARB, and we faxed them a copy of a letter from the ARB research contract manager. Responses were recorded immediately in a Microsoft Access™ database.

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[4] The mailing list provider's criteria for this initial estimate were that the facility be in California and that at least one of the SIC codes associated with it was on our list of 136. Later, we restricted the facilities to those whose ***primary*** SIC codes were on our final list.

[5] A memorandum on the pre-pilot survey of OEM coating users was submitted to the ARB on July 6, 2001 (Rogozen, 2001c).

[6] If there were fewer than ten facilities in an SIC code, then all the qualifying facilities were chosen.

Our overall response rate was 75.1 percent. At least one response was obtained for each SIC code, and the rate within SIC codes ranged from 40 to 100 percent. We decided to keep the ten SIC codes for which there was at least one positive response. Using the binomial distribution, we calculated the probability that there would be at least three users out of a sample of 20 from each SIC code (or fewer if there are fewer than 20 facilities in the state). This probability ranged from 0.09 (SIC 3639) to 1.00 (SIC 3634).

2.2.2.3 Additional SIC Codes to Include in the Survey

At the end of the pre-pilot survey, 125 SIC codes were in the sampling frame. To these we added 55 SIC codes that were identified in the searches of the San Joaquin Valley Unified Air Pollution Control District permit files and in CEIDARS II, but had not been part of the original 136. We ended up with 180 four-digit SIC codes.

2.2.3 Pilot Survey

Between July 6 and August 31, 2001, we conducted a pilot survey of OEM coatings users.[7] The purpose of the survey was to identify areas where the survey instruments and methods could be improved and to obtain initial estimates of some of the survey variables.

2.2.3.1 Methods and Response

The pilot survey's potential sample consisted of 176 facilities, each selected at random from one of the final four-digit SIC codes remaining after the pre-pilot survey.[8] We selected only facilities for which the SIC code of interest was the *primary* SIC code. Each company was mailed an envelope containing a cover letter, a six-page questionnaire, and an explanatory letter from the ARB. The questionnaire differed from the one used for the main survey (see Section 2.2.5) in that (1) it did not request quantities of coatings and solvents used, (2) it did not ask for the names of coatings and solvents manufacturers and distributors, and (3) it included a form for the respondent to provide comments and suggestions. A Microsoft Access™ database generated mailing labels, kept track of the response status of each facility, and recorded data provided on the responses.

Of the 176 facilities in the pilot survey, 12 (7 percent) were found or presumed to be out of business. Of the remaining 164 facilities, 11 provided data, 104 were ineligible (e.g., were manufacturers but did not apply coatings), 20 refused explicitly to cooperate, and 29 did not respond.

2.2.3.2 Implications of Findings for the Main Survey

After the pilot survey was completed, we held several discussions with the ARB about changing the scope of the survey of OEM coatings users. It was decided to expand it to ask respondents to report quantities of coatings and solvents used, as was already being

[7] A full report on the pilot survey was submitted to the ARB on September 20, 2001 (Rogozen, 2001a). The following discussion focuses on findings relevant to the main survey.

[8] For four of the 180 primary SIC codes selected in Section 2.2.2.3, there were no California firms.

done in the survey of commercial painters. Changes to the survey materials and procedures were as follows.

Changes to Survey Forms

Given the aforementioned change in scope, it was necessary to redesign the questionnaire substantially. The following were the major changes:

- Form 2 was completely revised: it no longer asked the manufacturers to state whether they used thinners and/or cleanup solvents for each of several coating types; instead it asked for very detailed information on solvent use;
- Form 3 (Operating Schedule) was reduced from two pages to one;
- Instead of reporting activity for each day of the week, respondents had only to distinguish among weekdays, Saturday and Sunday;
- Diurnal activity patterns were assumed to apply to both weekday and weekend activity;
- Form 4 (Influence of Weather on Activity) was simplified and reorganized;
- Form 5 (Survey Recipient Feedback) was replaced with a new form on which respondents were asked to list the manufacturers and/or distributors of their coatings and solvents;[9] and
- The backup letter from the ARB Project Manager was customized for this survey

Changes to Survey Procedures

- The survey forms were printed by a commercial printing and mailing service, rather than prepared and mailed in-house;
- If the presumed contact at a given facility was not available, we asked for a "manufacturing engineer" or "operations manager;" we did not leave detailed messages for presumed contacts at each facility;
- We limited our follow-up calls to five; and
- We included stamped, self-addressed envelopes with the survey packages

[9] This information was used to generate additional leads for the OEM coatings manufacturers survey. (See Section 2.1.)

2.2.4 Selection of the Main Survey Potential Sample

For the main survey, we used all but one of the 176 four-digit SIC codes used in the pilot survey. The exception is SIC 2952 (Asphalt Felts and Coatings). Examination of the definition of this SIC code showed that it applied to the *manufacture*, not the *use*, of coatings.[10] The final four-digit SIC codes are shown in Table 2-3.

Our proposed budget for this portion of the project assumed that the potential sample of OEM coating users would be 5,400. That number was based on the assumption that there would be 54 relevant SIC codes; that we would need a sample of 20 facilities in each SIC code to obtain reasonably small confidence limits about our findings; and that we would obtain a 20-percent response rate. As a "worst case," assume that the proportion of responses with useful data in the main survey is the same as that in the pilot survey. This proportion is 11/176. Applying this to the 5,400 budgeted facilities would result in 337.5 useful responses, or about 2 per four-digit SIC code. This would not be acceptable. Instead, we aggregated the remaining 175 four-digit SIC codes into 15 two-digit SIC codes. The expected number of responses per two-digit SIC code became 22.5, which would appear to be adequate.

Table 2-4 shows the two-digit SIC codes that were sampled. Note that we did **not** give the mailing list provider a list of two-digit codes to use as search criteria, as many four-digit codes within each two-digit group are not relevant. Instead, we used the list of four-digit codes in Table 2-4.

2.2.5 Survey Instruments

Every manufacturer in the potential sample was mailed a survey "package" containing the following:

- A cover letter from Harding ESE, Inc.;
- A five-form questionnaire;
- A letter from the ARB; and
- A stamped, self-addressed return envelope

Examples of the letters and forms are in Appendix A. The cover letter and Forms 1, 4, and 5 were printed on 11-inch x 17-inch stock and folded into a "booklet;" Forms 2 and 3 were printed on 8.5-inch x 11-inch stock and inserted into the booklet. Addresses from the survey management database (see Section 2.2.6) were printed on the cover letter and the package was mailed in a window envelope.

The cover letter introduced the survey, stated its purpose, promised that information provided would be published in summary form only and would not be associated with any particular manufacturer, and briefly described the forms. Form 1 asked for basic facility information (address, contact person, etc.), and asked for the number of employees. We

[10] The definition is available on the Internet at www.osha.gov/cgi-bin/sic/sicser2.

Table 2-3

FOUR-DIGIT SIC CODES USED IN MAIN SURVEY

SIC Code	Description	SIC Code	Description
2033	Canned Fruits Vegetables & Preserves	2673	Plastics Foil & Coated Paper Bags
2048	Prepared Feeds For Animals & Fowls	2679	Converted Paper & Paperboard Prods Nec
2063	Beet Sugar	3069	Fabricated Rubber Products Nec
2084	Wine Brandy & Brandy Spirits	3086	Plastics Foam Products
2085	Distilled & Blended Liquors	3088	Plastics Plumbing Fixtures
2086	Bottled & Canned Soft Drinks	3089	Plastics Products Nec
2221	Broadwoven Fabric Mills-Manmade & Silk	3211	Flat Glass
2261	Finishers-Broadwoven Fabrics-Cotton	3231	Glass Products Made Of Purchased Glass
2269	Finishers Of Textiles Nec	3272	Concrete Prods Except Block & Brick
2295	Coated Fabrics-Not Rubberized	3281	Cut Stone & Stone Products
2339	Womens Misses & Juniors Outerwear Nec	3312	Steel Works & Blast Furnaces
2394	Canvas & Related Products	3316	Cold-Rolled Steel Sheet Strip & Bars
2396	Automotive Trimmings & Apparel Findings	3317	Steel Pipe & Tubes
2421	Sawmills & Planing Mills-General	3411	Metal Cans
2426	Hardwood Dimension & Flooring Mills	3412	Metal Shipping Barrels Drums Kegs/Pails
2431	Millwork	3423	Hand & Edge Tools
2434	Wood Kitchen Cabinets	3429	Hardware Nec
2435	Hardwood Veneer & Plywood	3432	Plumbing Fixture Fittings & Trim
2439	Structural Wood Members Nec	3433	Heating Equipment
2441	Nailed & Lock Corner Wood Boxes & Shook	3441	Fabricated Structural Metal
2449	Wood Containers Nec	3442	Metal Doors Sash Frames Molding & Trim
2451	Mobile Homes	3443	Fabricated Plate Work (Boiler Shops)
2452	Prefab Wood Buildings & Components	3444	Sheet Metal Work
2499	Wood Products Nec	3446	Architectural & Ornamental Metal Work
2511	Wood Household Furn Except Upholstered	3448	Prefabricated Metal Buildings
2512	Wood Household Furniture Upholstered	3449	Miscellaneous Structural Metal Work
2514	Metal Household Furniture	3451	Screw Machine Products
2517	Wood Tv & Radio Cabinets	3452	Bolts Nuts Screws Rivets & Washers
2519	Household Furniture Nec	3469	Metal Stampings Nec
2521	Wood Office Furniture	3471	Electroplating Plating & Polishing
2522	Office Furniture Except Wood	3479	Coating Engraving & Allied Svcs Nec
2531	Public Building & Related Furniture	3489	Ordnance & Accessories Nec
2541	Wood Office & Store Fixtures	3491	Industrial Valves
2542	Office & Store Fixtures Except Wood	3492	Fluid Power Valves & Hose Fittings
2591	Drapery Hardware & Window Blinds/Shades	3494	Valve & Pipe Fittings Nec
2599	Furniture & Fixtures Nec	3495	Wire Springs
2652	Setup Paperboard Boxes	3496	Miscellaneous Fabricated Wire Products
2655	Fiber Cans Tubes Drums & Similar Prods	3498	Fabricated Pipe & Pipe Fittings
2656	Sanitary Food Containers Except Folding	3499	Fabricated Metal Products Nec
2657	Folding Paperboard Boxes	3511	Steam Gas & Hydraulic Turbines
2671	Packaging Paper & Plastics Film-Coated	3523	Farm Machinery & Equipment
2672	Coated & Laminated Paper Nec	3524	Lawn & Garden Tractors/Home Lawn Equip

Table 2-3

FOUR-DIGIT SIC CODES USED IN MAIN SURVEY

(Continued)

SIC Code	Description	SIC Code	Description
3531	Construction Machinery & Equipment	3645	Residential Electric Lighting Fixtures
3532	Mining Machinery & Equipment	3646	Commercial Electric Lighting Fixtures
3533	Oil & Gas Field Machinery & Equipment	3648	Lighting Equipment Nec
3534	Elevators & Moving Stairways	3651	Household Audio & Video Equipment
3535	Conveyors & Conveying Equipment	3663	Radio & Tv Broadcasting Equipment
3536	Overhead Traveling Cranes & Hoists	3669	Communications Equipment Nec
3537	Industrial Trucks Tractors & Trailers	3672	Printed Circuit Boards
3541	Machine Tools-Metal Cutting Types	3674	Semiconductors & Related Devices
3542	Machine Tools-Metal Forming Types	3675	Electronic Capacitors
3544	Special Dies & Tools & Die Sets	3676	Electronic Resistors
3545	Cutting Tools & Machine Tool Access	3677	Electronic Coils & Transformers
3546	Power-Driven Hand Tools	3678	Electronic Connectors
3547	Rolling Mill Machinery & Equipment	3679	Electronic Components Nec
3552	Textile Machinery	3694	Elec Equip For Internal Comb Engines
3553	Woodworking Machinery	3699	Electrical Machinery Equip & Supls Nec
3554	Paper Industries Machinery	3711	Motor Vehicles & Passenger Car Bodies
3555	Printing Trades Machinery & Equipment	3713	Truck & Bus Bodies
3556	Food Products Machinery	3714	Motor Vehicle Parts & Accessories
3559	Special Industry Machinery Nec	3715	Truck Trailers
3561	Pumps & Pumping Equipment	3716	Motor Homes
3563	Air & Gas Compressors	3721	Aircraft
3564	Industrial & Commercial Fans & Blowers	3724	Aircraft Engines & Engine Parts
3565	Packaging Machinery	3728	Aircraft Parts/Auxiliary Equipment Nec
3567	Industrial Process Furnaces & Ovens	3731	Ship Building & Repairing
3569	General Industrial Machinery Nec	3732	Boat Building & Repairing
3571	Electronic Computers	3743	Railroad Equipment
3577	Computer Peripheral Equipment Nec	3751	Motorcycles Bicycles & Parts
3579	Office Machines Nec	3761	Guided Missiles & Space Vehicles/Parts
3581	Automatic Vending Machines	3764	Guided Missile/Space Vehicle Prop Units
3585	Air Conditioning & Heating Equipment	3769	Guided Missile/Space Vehicle Parts Nec
3596	Scales & Balances-Except Laboratory	3792	Travel Trailers & Campers
3599	Industrial & Commercial Machinery Nec	3795	Tanks & Tank Components
3612	Power & Distribution Transformers	3799	Transportation Equipment Nec
3613	Switchgear & Switchboard Apparatus	3812	Search Detection Systems & Instruments
3621	Motors & Generators	3823	Industrial Instruments For Measurement
3625	Relays & Industrial Controls	3825	Instruments For Measuring Electricity
3629	Electrical Industrial Apparatus Nec	3826	Laboratory Analytical Instruments
3631	Household Cooking Equipment	3827	Optical Instruments & Lenses
3632	Household Refrigerators & Freezers	3829	Measuring & Controlling Devices Nec
3634	Electric Housewares & Fans	3842	Orthopedic & Prosthetic Appliances
3635	Household Vacuum Cleaners	3844	X-Ray Apparatus & Tubes
3641	Electric Lamp Bulbs & Tubes	3861	Photographic Equipment & Supplies

Table 2-3

FOUR-DIGIT SIC CODES USED IN MAIN SURVEY

(Continued)

SIC Code	Description
3931	Musical Instruments
3944	Games Toys & Childrens Vehicles
3949	Sporting & Athletic Goods Nec
3991	Brooms & Brushes
3993	Signs & Advertising Specialties
3995	Burial Caskets
3999	Manufacturing Industries Nec

Table 2-4

TWO-DIGIT SIC CODES USED FOR THE MAIN SURVEY

SIC Code	Description
20	Food and Kindred Products
22	Textile Mill Products
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials
24	Lumber and Wood Products, Except Furniture
25	Household Furniture
26	Paper and Allied Products
30	Rubber and Miscellaneous Plastics Products
32	Stone, Clay, Glass, and Concrete Products
33	Primary Metal Industries
34	Metal Cans and Shipping Containers
35	Industrial and Commercial Machinery and Computer Equipment
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment
37	Transportation Equipment
38	Measuring, Analyzing and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks
39	Miscellaneous Manufacturing Industries

also asked how many gallons of "solvent-based" and water-based coatings were used in a typical year.

Form 2 asked the respondent to report the names and volumes of all solvents used for paint thinning and for equipment cleanup. We divided the solvents into the following general classes:

- Mineral spirits
- Lacquer thinner
- Acetone
- Denatured alcohol
- Isopropyl alcohol
- Methanol
- Methylene chloride
- Naphtha
- Toluene
- Xylene
- Other

Although we asked for material safety data sheets (MSDSs), we did not expect to receive many. We therefore asked the respondents to indicate the manufacturer and product name or number of the solvents that they used, so that we could obtain the MSDSs. Form 2 also asked for the number of ounces of thinner typically mixed per gallon of paint. Finally, the form let the respondent choose the year corresponding to the information provided. We preferred, but did not require, it to be between 1999 and 2001 inclusive.

Form 3 requested information on temporal patterns of thinning and cleanup solvent use. Measures included percentage of annual use by month; whether solvents were used on weekdays, Saturdays, or Sundays, for each season; and hours of the day in which paints and solvents were used, by season.

Form 4 sought data on the influence of unusually hot, cold, and inclement weather on coating and solvent use. For each situation, the respondent was given the option of stating that the weather had no effect on coating activities. Finally, Form 5 asked the facility to list the names of companies that supplied their coatings and solvents. We used this information to supplement the mailing list for the survey of OEM coating manufacturers.

2.2.6 Survey Database Management System

Company contact information (name, address, telephone number, etc.) was copied from the InfoUSA.com, Inc. database to a Microsoft Access™ database designed specifically for this project. A unique identification number ("UID") was assigned to each manufacturer. Fields for various types of data to be obtained through the survey, such as fax numbers, e-mail addresses, and numbers of employees, were included in a company data table. Other tables were set up to track the status of each company in the survey and to store response data. The database also included various queries to examine the tables, and forms for data entry. Many routine and *ad hoc* queries were used for various quality assurance measures.

As discussed above, respondents were asked to provide material safety data sheets (MSDSs) for the thinners and cleanup solvents that they reported. The survey database included tables and data entry forms to record, for each material, information on the

manufacturer, the density, total and reactive organic gases, and all reported information on chemical composition. To avoid the problem of multiple names for various common solvents, chemical species data were stored by Chemical Abstracts Service (CAS) Registry numbers.

2.2.7 Full Survey Printing and Mail-Out

UID numbers, contact names, facility names, and mailing addresses were copied to a "comma-separated values" (.csv) text file and given to a printing and mailing company. The mailing company printed and bar-coded the addresses on the cover letter in a position that would show through the window on the outgoing business envelope. The survey packages were mailed on July 18, 2002.

2.2.8 Follow-Up Activities

The first faxed response to the survey was received on July 19, 2002, and the first mailed response was received July 23, 2002. About a week after the mailing, we began calling manufacturers that had not yet responded. To avoid biasing the response, we randomly selected companies each day for the calling list. We asked each one if it had received the survey forms and offered our assistance in filling them out. Other follow-up activities are described in the following sections.

2.2.8.1 Resolving Incorrect Addresses

More than 90 surveys were returned by the U.S. Postal Service (USPS). We attempted to obtain correct addresses by calling the last known telephone number of the firm and/or searching for it on the Internet. Several facilities were sent "original mailings" in a new envelope. If the USPS returned the mailing after this exercise, the facility was eliminated from the survey.

2.2.8.2 Re-Sending Questionnaires

Many of the manufacturers told us that they had discarded or lost the survey package, or had never received it. After verifying their addresses and/or fax numbers, we re-sent the package. By the end of the survey, we had re-mailed 26 questionnaire packages and re-faxed another 63.

2.2.8.3 Researching Material Characteristics

Only a handful of manufacturers returned MSDSs with their responses. It fell upon us to contact solvent manufacturers and obtain material safety data sheets and other product information. Each combination of manufacturer and product was assigned a unique product ID number for the MSDS database.

2.2.8.4 Clarification of Survey Responses

About 20 percent of the returned questionnaires were not filled out completely or contained unreadable or ambiguous responses. Manufacturing firms with deficient responses were telephoned, faxed and e-mailed to complete or clarify the information.

2.2.9 Survey Data Processing and Calculations

Survey data were entered into the following tables in the Access database:

- FACILITIES – Name, address, contact information, etc.
- FACILITYWIDE DATA - Gallons of solvent- and water-based coating used by each facility
- SOLVENT USE DATA – Solvent category (mineral spirits, lacquer thinner, etc.); product code; gallons of thinner, cleanup solvent and water-based coating additive used; and ounces of thinner added per gallon of coating
- MSDS DATA – Name of solvent formulation, identification code, manufacturer code, solvent category, density and ROG and TOG contents
- MSDS SPECIES – For each solvent formulation, a list of the CAS numbers and names of its ingredients, along with the weight percentage of each
- MANUFACTURERS – Names, addresses, telephone numbers and contacts of the manufacturers of the reported solvent formulations

We performed a variety of calculations, many of which are described in later sections of this report, on the survey data. For most types of "accounting" calculations, such as reported gallons of thinner by solvent category, we used Access' query utility. For more complex calculation, we used Access queries to extract the needed information and then exported it to Microsoft Excel™.

One calculation technique that requires additional discussion is "bootstrap sampling," which was used to generate 90-percent confidence intervals about many calculated means, including weighted means. This method was used where:

- Data sets had many zero values, so that the lower bounds of confidence intervals calculated by conventional means would be negative;
- Data were not normally distributed;
- It gave "tighter" confidence intervals than would conventional methods

In bootstrap sampling one begins with an actual data set, such as gallons of solvent reported by each facility in the survey. The next step is to calculate an unweighted or weighted mean, as appropriate. Then, one draws a large number of random samples (with replacement) from the actual data set and calculates the mean value for each sample. These means are generally normally distributed; their variance is taken as the variance of the mean calculated with the entire original data set. We used Resampling Stats software (Bruce et al., 2000) to perform the calculations. The following is an outline of the computation approach for an example situation: calculating the weighted average VOC content of the lacquer thinners reported by survey respondents.

Suppose that we have collected data on five lacquer thinner products, each with a different VOC content. Let the VOC values be $\{c_1, c_2, c_3, c_4, c_5\}$ and their corresponding reported volumes be $\{V_1, V_2, V_3, V_4, V_5\}$. Then the weighted mean VOC content is:

$$\text{Mean} = (V_1c_1 + V_2c_2 + V_3c_3 + V_4c_4 + V_5c_5)/(V_1 + V_2, + V_3 + V_4 + V_5)$$

To estimate a confidence interval about this weighted mean, we set up an imaginary "urn" containing the reported VOC values (c_1, c_2, etc.). The urn contains V_1 copies of c_1, V_2 copies of c_2, etc. In this way, the probability of randomly "selecting" a value of c_1, for example, equals V_i's fraction of the total reported solvent volume. Using the bootstrap sampling software, we "resample" the original data set and collect five new values of VOC. We then calculate the mean for that new sample as the simple (unweighted) mean of the five values selected. The calculated mean value is stored in a temporary table. Then the data set is "resampled" again and again. (For most of our analyses, we resampled 5,000 times.) The software calculates the mean of all the resampled means. In most cases this value is very close to the weighted mean calculated by conventional means. Then the software determines the 90-percent confidence interval by putting all the resample mean values in order and finding the one that is greater than only five percent of the total number of resample mean values, and one that is greater than all but five percent of the resample means.

2.2.10 Survey Quality Assurance/Quality Control

In general, we followed the quality assurance plan that was prepared for this project (PES, 2002). Throughout the survey, the Principal Investigator reviewed survey responses for completeness and reasonableness, and often requested clarification and/or correction of information. To ensure consistency of interpretation, the Principal Investigator entered all results into the Access database. Numerous *ad hoc* queries were used to test the internal consistency of the results. For example, sums of monthly activity percentages had to be between 99.99 and 100.1. Sums of species weight percentages were not allowed to exceed 100.

Most survey results, such as volumes of solvents used, were computed on several bases (e.g., by solvent material, by county, by air basin, etc.) These results were checked to ensure that they were all consistent with each other.

2.3 SURVEY OF COMMERCIAL PAINTERS

2.3.1 Objective

The objectives of the survey of commercial painters were to obtain the following information from companies that apply architectural and industrial maintenance (AIM) coatings:

- Quantities and types of thinners and cleanup solvents associated with AIM coatings and their association with different AIM bases;
- Data on composition of thinners and cleanup solvents;
- Temporal patterns of coating and thinner and cleanup solvent use; and
- Effect of weather on patterns of use of thinners and cleanup solvents for AIM coatings

As part of the first objective, we were to obtain the information necessary to develop an emission factor in units of pounds thinning and/or cleanup solvent to gallons of solvent-borne AIM coatings applied.

2.3.2 Sampling Frame for the Survey

The sampling frame for this survey was all commercial painters in California. "Commercial painters" included firms whose sole business was painting residences, industrial and commercial property and other structures, as well as construction and maintenance firms with in-house painting divisions.

On April 18, 2001, we received from InfoUSA.com (a mailing list provider) a database of 4,589 companies in standard industrial classification (SIC) codes SIC 172101 (Painters) and 172102 (Painting Contractors – Commercial & Industrial) located in California. The list included 166 companies for which one of our search SIC codes was a *secondary* SIC code; i.e., painting was not the main activity.[11] Most of the non-painting primary SIC codes had something to do with painting. For example, many building contractors and drywall contractors were listed. These companies are likely to do a significant amount of painting, and were left in the sampling frame. However, the list included several SIC codes for which commercial painting was unlikely, such as 523107 (Paint – Retail). We attempted to telephone all the companies whose presence in the sampling frame was questionable. We verified that many of these indeed were not commercial painters. In addition, we found several companies to be out of business. We eliminated 39 companies from the mailing list, leaving 4,550 in the sampling frame.

Using air basin maps obtained from the ARB's web site, printed road maps, and various online mapping databases, we determined the air basin for every company on the mailing

[11] In our search criteria for InfoUSA.com, we did not require SIC codes 172101 and 172102 to be *primary* SIC codes.

list. Tables 2-5 and 2-6 show the geographic distribution of the sampling frame, by county and air basin, respectively.

2.3.3 Pilot Survey

2.3.3.1 Methods and Response

In July-September, 2001, we conducted a pilot survey of commercial painters in California.[12] The purpose of the pilot survey was to identify areas where the survey instruments could be improved and to obtain initial estimates of the variance in important survey variables.

We chose 69 companies at random from the 4,550 companies in the sampling frame. Each company was mailed an envelope containing a cover letter, a six-page questionnaire, and an explanatory letter from the ARB. Neither return envelopes nor return postage were included in the survey packages. The questionnaire was similar to the one used for the main survey (see Section 2.3.5), except that it included a form for the respondent to provide comments and suggestions. A Microsoft Access™ database generated mailing labels, kept track of the response status of each facility, and recorded data provided on the responses, including material safety data sheets (MSDSs). We attempted to telephone all painting contractors that did not respond to the survey, to encourage a response, or to clarify information provided on the forms.

Of the 69 facilities in the pilot survey, 9 were found or presumed to be out of business.[13] Of the remaining 59 firms, 7 provided data, 7 refused explicitly to participate, and 45 never responded.

2.3.3.2 Implications of Findings for the Main Survey

How we used the pilot survey results to design the potential sample for the main survey is discussed in Section 2.3.4. Other implications for the main survey are discussed here.

Changes to Survey Forms

- The pilot survey asked recipients if they applied "architectural and industrial maintenance coatings." This is an emission inventory term, not painters' jargon, and was confusing to some respondents. On the final survey form, we asked recipients, "Are you a contractor who applies coatings to residences, commercial buildings, industrial plants, bridges or other structures?"

- The pilot survey listed three choices for solvents used: mineral spirits, lacquer thinner, and "other." We determined that many more alternatives were necessary; and

[12] A full report on the pilot survey of commercial painters was submitted to the ARB on November 20, 2001 (Rogozen, 2001d). The following discussion focuses on findings relevant to the main survey.
[13] Four firms stated that they were out of business, and the U.S. Postal Service returned surveys for another five.

Table 2-5

NUMBER OF COMMERCIAL PAINTERS IN SAMPLING FRAME, BY COUNTY

County	Count	County	Count
Alameda	159	Orange	593
Alpine	4	Placer	58
Amador	6	Plumas	7
Butte	36	Riverside	181
Calaveras	14	Sacramento	175
Colusa	3	San Benito	5
Contra Costa	140	San Bernardino	181
Del Norte	2	San Diego	295
El Dorado	34	San Francisco	127
Fresno	105	San Joaquin	63
Glenn	2	San Luis Obispo	56
Humboldt	23	San Mateo	146
Imperial	6	Santa Barbara	77
Inyo	5	Santa Clara	248
Kern	57	Santa Cruz	59
Kings	9	Shasta	29
Lake	15	Sierra	0
Lassen	6	Siskiyou	7
Los Angeles	918	Solano	42
Madera	8	Sonoma	107
Marin	102	Stanislaus	60
Mariposa	3	Sutter	10
Mendocino	18	Tehama	8
Merced	24	Trinity	1
Modoc	1	Tulare	26
Mono	7	Tuolumne	22
Monterey	68	Ventura	102
Napa	22	Yolo	23
Nevada	39	Yuba	6
		Total	4,550

Table 2-6

NUMBER OF COMMERCIAL PAINTERS IN SAMPLING FRAME, BY AIR BASIN

Air Basin	Estimated No. of Painters
Great Basin Valleys	16
Lake County	15
Lake Tahoe	19
Mojave Desert	61
Mountain Counties	126
North Central Coast	132
North Coast	54
Northeast Plateau	14
Sacramento Valley	372
Salton Sea	62
San Diego	295
SF Bay Area	1,041
San Joaquin Valley	344
South Central Coast	235
South Coast	1,764
Total	**4,550**

- The backup letter from the ARB Project Manager was customized for the survey

Changes to Survey Procedures

- Survey forms were printed by a commercial printing and mailing service, rather than prepared and mailed in-house;
- We tried to concentrate our follow-up calling in the late afternoon and early evening, to catch painters at home;
- We decided to limit follow-up calls to five;[14] and
- We included stamped, self-addressed envelopes with the survey packages

[14] Given the poor response in the main survey, we occasionally tried more than five follow-up calls.

2.3.4 Selection of the Main Survey Potential Sample

2.3.4.1 Sample Size

The Request for Proposal required that whole-state and by-county emission factors be within ± 10 percent and ± 15 percent, respectively, of the mean at a 90-percent confidence level. The only statistic from the pilot survey that was useful for planning the main survey was the average VOC emissions per painting firm. For emissions from thinner use, the sample mean and sample standard deviation were 543 and 664 lb/yr, respectively. Using the state-wide criterion of 10 percent,[15] the maximum allowable half-width of the 95-percent confidence interval is (0.1)(543) = 54.3 lb/yr.

The required sample size, with finite population correction, is (Shell, 1997):

$$n = Ns^2/[(N-1)(E/z)^2 + s^2] \quad [2\text{-}1]$$

where

- N = Number in the sampling frame
- s = Population variance (as estimated by the sample standard deviation)
- E = Tolerated error
- z = Factor for confidence interval in normal distribution

In this case, z = 1.645 for a 90-percent confidence interval. N is estimated by assuming that the ratio of eligible painting companies to the total surveyed will be the same as in the pilot survey, i.e. 59/69. The sampling frame is thus (59/69)(4550) = 3,891. Substituting known values into the formula yields a required sample size of **367**. We had budgeted for a potential sample of 2,321 firms. The necessary response rate was therefore (367/2321) = 0.158, or **15.8 percent**. The pilot survey response rate was only 7 of 69, or 10.1 percent. We had, therefore, to find ways of increasing the likelihood of responses.

2.3.4.2 Allocation to Air Basins

Because statewide quantities and variances thereof are not as useful to the ARB as are those for individual basins, our goal, it would be preferable to obtain "acceptable" confidence intervals about estimates for means and totals for each basin.

To do this, we first applied the preceding equation to each basin. With no data to demonstrate otherwise, we assumed that the variance in the thinner emissions would be the same in each basin.[16] Following the RFP's requirements, we set the target confidence interval half-width to 15 percent of the mean, rather than the 10 percent value used for a statewide estimate. Table 2-7 shows how we calculated the necessary sample size in each basin. First, we adjusted the sampling frame for each basin by assuming that the

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[15] A much larger sample size is needed to develop basin-specific estimates, as is discussed later; use of a state-wide criterion gives us the absolute minimum number of responses.

[16] Our intuitive guess was that the variance is <u>not</u> the same in each basin. Larger basins would be expected to have a much greater variety of commercial painting firm sizes than would small basins. However, the pilot survey did not obtain enough responses to be able to obtain variance by basin.

Table 2-7

ALLOCATION OF POTENTIAL SAMPLE TO AIR BASINS

Air Basin	Estimated No. of Painters	No. Likely to be Eligible	Required Sample Size	Potential Sample
Great Basin Valleys	16	14	13	14
Lake County	15	13	12	13
Lake Tahoe	19	16	15	16
Mojave Desert	61	52	41	52
Mountain Counties	126	108	68	108
North Central Coast	132	113	70	113
North Coast	54	46	37	46
Northeast Plateau	14	12	11	12
Sacramento Valley	372	318	115	255
Salton Sea	62	53	41	53
San Diego	295	252	105	233
SF Bay Area	1,041	890	150	333
San Joaquin Valley	344	294	112	249
South Central Coast	235	201	95	201
South Coast	1,764	1,508	161	357
Total	**4,550**	**3,890**	**1,046**	**2,055**

ratio of eligible painting companies to the total surveyed will be the same as in the pilot survey, i.e. 59/69. Using the preceding equation, we then calculated the necessary sample size for each basin. As seen in Table 2-7, the total required sample size was considerably higher than the one necessary if all the basins' results are pooled (1,046 vs. 367). As the project budget allowed for a potential sample of 2,321, we adjusted each basin's potential samples as follows, where R_j is the minimum required sample size for the jth basin, as calculated in the table.

$$P_j = 2321 (R_j/\Sigma R_j)$$

For basins for which this apportionment resulted in a value of P_j that exceeded the size of the sampling frame, we decided to sample all the firms in the basin. This limitation of the allocation resulted in a total potential sample size of 2,055, rather than 2,321. We held the remaining 266 firms in reserve, planning to use them late in the survey to "beef up" the potential sample in basins that had larger variances than expected.[17]

[17] These "reserve" firms were not surveyed.

2.3.5 Survey Instruments

Every painting contractor in the potential sample was mailed a survey "package" containing the following:

- A cover letter from Harding ESE, Inc.;
- A four-form questionnaire;
- A letter from the ARB; and
- A stamped, self-addressed return envelope

Examples of the letters and forms are in Appendix A. The cover letter, Forms 1 and 4, and the ARB letter were printed on 11-inch x 17-inch stock and folded into a "booklet;" Forms 2 and 3 were printed on 8.5-inch x 11-inch stock and inserted into the booklet. Addresses from the survey management database (see Section 2.3.6) were printed on the cover letter and the package was mailed in a window envelope.

The cover letter introduced the survey, stated its purpose, promised that information provided would be published in summary form only and would not be associated with any particular painting contractor, and briefly described the forms. Form 1 asked for basic facility information (address, contact person, etc.), and asked for the number of painters in the field during periods of maximum work. We also asked how many gallons of "oil-based"[18] and water-based coatings were used in a typical year.

Form 2 asked the respondent to report the names and volumes of all solvents used for paint thinning, equipment cleanup, and as additives to water-based coatings. We divided the solvents into the following general classes:

- Mineral spirits
- Lacquer thinner
- Acetone
- Denatured alcohol
- Isopropyl alcohol
- Methanol
- Methylene chloride
- Naphtha
- Toluene
- Xylene
- Other

Although we asked for material safety data sheets (MSDSs), we did not expect to receive many. We therefore asked the painters to indicate the manufacturer and product name or number of the solvents that they used, so that we could obtain the MSDSs. Form 2 also asked for the number of ounces of thinner typically mixed per gallon of paint. It also asked for the percentage of cleanup solvents that were used for spray equipment, brushes

[18] As we learned in the survey, we should have asked for "solvent-based," instead of "oil-based," coatings.

and rollers, and other equipment. Finally, the form let the respondent choose the year corresponding the information provided. We preferred, but did not require, it to be between 1999 and 2001 inclusive.

Form 3 requested information on temporal patterns of thinning and cleanup solvent use. Measures included percentage of annual use by month; whether solvents were used on weekdays, Saturdays, or Sundays, for each season; and hours of the day in which paints and solvents were used, by season. Finally, Form 4 sought data on the influence of unusually hot, cold, and inclement weather on coating and solvent use. For each situation, the respondent was given the option of stating that the weather had no effect on coating activities.

2.3.6 Survey Database Management System

Company contact information (name, address, telephone number, etc.) was copied from the InfoUSA.com, Inc. database to a Microsoft Access™ database designed specifically for this project. A unique identification number ("CPID") was assigned to each commercial painting company. Fields for various types of data to be obtained through the survey, such as fax numbers, e-mail addresses, and numbers of employees, were included in a company data table. Other tables were set up to track the status of each company in the survey and to store response data. The database also included various queries to examine the tables, and forms for data entry. Many routine and *ad hoc* queries were used for various quality assurance measures.

As discussed above, respondents were asked to provide material safety data sheets (MSDSs) for the thinners and cleanup solvents that they reported. The survey database included tables and data entry forms to record, for each material, information on the manufacturer, the density, total and reactive organic gases, and all reported information on chemical composition. To avoid the problem of multiple names for various common solvents, chemical species data were stored by Chemical Abstracts Service (CAS) Registry numbers.

2.3.7 Full Survey Printing and Mail-Out

Using the allocation guidelines in Table 2-7, we randomly selected 2,055 commercial painting firms for the main survey. CPID numbers, contact names, facility names, and mailing addresses were copied to a "comma-separated values" (.csv) text file and given to a printing and mailing company. The mailing company printed and bar-coded the addresses on the cover letter in a position that would show through the window on the outgoing business envelope. The survey packages were mailed on April 16, 2002.

2.3.8 Follow-Up Activities

The first faxed response to the survey was received on April 19, 2002, and the first mailed response was received the day after that. About a week after the mailing, we began calling painting companies that had not yet responded. To avoid biasing the response geographically, we randomly selected companies each day for the calling list. We asked

each one if it had received the survey forms and offered our assistance in filling them out. Other follow-up activities are described in the following sections.

2.3.8.1 Resolving Incorrect Addresses

Because the commercial painters database was a year old by the time we used it for the main survey, about 330 surveys were returned by the U.S. Postal Service (USPS). We attempted to obtain correct addresses by calling the last known telephone number of the painting firm and/or searching for it on the Internet. If the USPS returned the mailing after this exercise, the facility was eliminated from the survey.

2.3.8.2 Re-Sending Questionnaires

Many of the contacted painters told us that they had discarded or lost the survey package, or had never received it. After verifying their addresses and/or fax numbers, we re-sent the package. By the end of the survey, we had re-mailed 47 surveys and re-faxed another 149.

2.3.8.3 Researching Material Characteristics

Only a handful of commercial painters returned MSDSs with their responses. It fell upon us to contact solvent manufacturers and obtain material safety data sheets and other product information. Each combination of manufacturer and product was assigned a unique product ID number for the MSDS database.

2.3.8.4 Clarification of Survey Responses

About 20 percent of the returned questionnaires were not filled out completely or contained unreadable or ambiguous responses. Painting firms with deficient responses were telephoned, faxed and e-mailed to complete or clarify the information.

2.3.9 Survey Data Processing and Calculations

The same data processing and calculation methods that were described in Section 2.2.9 for the OEM coating user survey were used for the commercial painters survey.

2.3.10 Survey Quality Assurance/Quality Control

We used the same quality assurance/quality control procedures as were described for the OEM coatings users survey. (See Section 2.2.10.)

2.4 SURVEY OF CALIFORNIA HOMEOWNERS

2.4.1 Objective

The objective of this survey was to obtain data on temporal patterns of, and weather influences upon, painting by owner-occupied single-family households in California. The survey complemented the survey of commercial painters, which was described in Section 2.3, although its emphasis was upon the temporal patterns and weather influences. It requested only limited quantitative data on solvent use associated with architectural coatings.

2.4.2 Selection of the Survey Sample

The sampling frame for this survey comprised all owner-occupied residences in California for which both addresses and telephone numbers were available. This definition differed in two respects from the one originally proposed. First, in the proposal, only single-family households were to be included. We expanded the sampling frame to include condominiums and other multi-family dwellings, since their owners also use architectural coatings inside individual units. Second, in the proposal we included all households, whether or not they had listed telephone numbers. Because we decided to conduct this survey primarily by telephone, and did not wish to use random-digit dialing (see below), limiting the sampling frame to residences with listed telephone numbers was the only practical approach.

A review of an on-line version of a database maintained by InfoUSA.com indicated that there are 2,118,147 households in the sampling frame.[19] In our proposal, we estimated that a potential sample of 4,025 residences would be necessary to achieve the project's data quality objectives. As it turned out, the assumptions upon which that estimate was based were not supported by the results of the pilot survey. (See Section 2.4.3.) Nevertheless, we obtained a mailing list database of 4,025 California owner-occupied residences with listed telephone numbers from InfoUSA.com. The database supplier was instructed to select the households randomly from the statewide sampling frame.[20]

Table 2-8 shows how the sampling frame and the potential sample were distributed by county. A chi-square analysis showed that the potential sample's distribution by county was not significantly different from that of the sampling frame ($X^2 = 57.976$, d.f. = 58, $p < 0.23$). Note that six counties (Alpine, Amador, Modoc, Mono, Sierra and Trinity) are not represented in the potential sample. For five of these counties, this was not surprising; the expected size of a randomly selected sample was less than one. For Amador County, four households were expected.

Table 2-9 shows how the potential sample was distributed by air basin. Because many counties are split among two or more air basins, we could not determine the distribution of the sampling frame by basin.

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[19] As will be discussed in Chapter 6, this figure is significantly lower than the value reported by the 2000 U.S. Census.

[20] The database supplier had no practical way of randomly selecting households by county or air basin.

Table 2-8

DISTRIBUTION OF SAMPLING FRAME AND POTENTIAL SAMPLE, BY COUNTY

County	Sampling Frame	Potential Sample	County	Sampling Frame	Potential Sample
Alameda	94,845	168	Orange	192,433	391
Alpine	34	0	Placer	22,267	34
Amador	2,109	0	Plumas	1,253	1
Butte	19,320	33	Riverside	110,748	198
Calaveras	2,392	2	Sacramento	69,630	144
Colusa	1,176	5	San Benito	3,698	5
Contra Costa	84,203	152	San Bernardino	83,147	177
Del Norte	1,840	1	San Diego	188,292	370
El Dorado	16,217	27	San Francisco	39,799	72
Fresno	43,762	91	San Joaquin	33,400	78
Glenn	2,724	7	San Luis Obispo	22,219	47
Humboldt	9,344	16	San Mateo	56,682	111
Imperial	7,008	9	Santa Barbara	29,126	50
Inyo	1,668	4	Santa Clara	114,819	229
Kern	43,067	80	Santa Cruz	18,013	24
Kings	6,766	12	Shasta	13,158	20
Lake	4,883	9	Sierra	7	0
Lassen	1,589	6	Siskiyou	5,748	13
Los Angeles	468,985	884	Solano	26,399	49
Madera	7,623	9	Sonoma	35,826	65
Marin	22,234	59	Stanislaus	28,567	56
Mariposa	1,853	3	Sutter	6,412	8
Mendocino	7,009	11	Tehama	4,562	6
Merced	13,602	26	Trinity	52	0
Modoc	403	0	Tulare	22,479	33
Mono	56	0	Tuolumne	5,960	15
Monterey	20,174	35	Ventura	58,704	100
Napa	10,875	24	Yolo	11,217	21
Nevada	13,790	26	Yuba	3,979	9
Totals				2,118,147	4,025

Table 2-9

DISTRIBUTION OF THE POTENTIAL SAMPLE BY AIR BASIN

Basin Code	Basin Name	Number in Potential Sample
GBV	Great Basin Valleys	4
LC	Lake County	9
LT	Lake Tahoe	5
MC	Mountain Counties	73
MD	Mojave Desert	105
NC	North Coast	38
NCC	North Central Coast	64
NEP	Northeast Plateau	19
SC	South Coast	1,505
SCC	South Central Coast	197
SD	San Diego	370
SF	San Francisco Bay Area	870
SJV	San Joaquin Valley	367
SS	Salton Sea	67
SV	Sacramento Valley	332
	Total	4,025

2.4.3 Pilot Survey

In August and September, 2001, we conducted a pilot survey of homeowners in California.[21] The pilot survey had three objectives:

- To identify areas where the survey instruments could be improved;
- To test different ways of increasing the response rate; and
- To obtain initial estimates of the variance in important survey variables

2.4.3.1 Selection of the Pilot Survey Potential Sample

For the pilot survey, we attempted to select three households at random for each county represented in the main survey potential sample. Ideally, the potential sample would be 3 x 52 = 156 households. However, because our database contained only 0, 1, or 2 entries for several counties, the maximum possible potential sample size was 151. Table 2-10

[21] A full report on the pilot survey of California homeowners was submitted to the ARB on October 3, 2001 (Rogozen, 2001b). The following discussion focuses on findings relevant to the main survey.

Table 2-10

DISTRIBUTION OF PILOT SURVEY POTENTIAL SAMPLE BY AIR BASIN

Basin Code	Basin Name	Number in Potential Sample
GBV	Great Basin Valleys	3
LC	Lake County	3
LT	Lake Tahoe	1
MC	Mountain Counties	15
MD	Mojave Desert	0
NC	North Coast	7
NCC	North Central Coast	9
NEP	Northeast Plateau	6
SC	South Coast	12
SCC	South Central Coast	9
SD	San Diego	3
SF	San Francisco Bay Area	24
SJV	San Joaquin Valley	24
SS	Salton Sea	3
SV	Sacramento Valley	32
	Total	151

shows how the pilot survey potential sample was distributed by air basin. The distribution was somewhat different from that of the main survey potential sample. For example, there were no households in the Mojave Desert Air Basin and there were more in the Mountain Counties Air Basin than in the much more populous South Coast Air Basin. These disparities were not important in the pilot survey, since its purpose was to evaluate materials and methods and obtain only some preliminary data.

2.4.3.2 Pilot Survey Methods

The telephone script and the database management system for the homeowners pilot survey were the same as for the main survey, and are described in Sections 2.4.5 and 2.4.6, respectively. To test the efficacy of different survey strategies, we divided the potential sample into four roughly equal parts. Half the homeowners were mailed a notification letter and half were not. Half were offered a grocery certificate and half were not. Table 2-11 shows the groupings.

Table 2-11

MODES OF INITIAL CONTACT AND INCENTIVES FOR HOMEOWNERS SURVEY

	Incentive	No Incentive	Totals
Letter	38	35	73
No Letter	39	39	78
Totals	77	74	151

A one-page letter on PES stationery was mailed to half the residences in the pilot survey potential sample.[22] The letter stated the purpose of the project and summarized the survey and the questions to be asked. It said that the recipient had been chosen at random "from a list of California residents," and notified the recipient that he or she would be called soon. Recipients were assured that no personal or financial information would be sought, that they would be anonymous, and that we were not trying to sell them anything. The letters to the homeowners in the "Incentive" group offered a $5 gift certificate to a major grocery store chain to qualified homeowners that responded completely.

Household pilot survey telephone calls were made from August 22, 2001 to September 18, 2001. All calls were made on weekdays. If the call reached an answering machine or voice mail, we did not leave a message. We kept a running record of the date and time of the latest call to each household, so that we could later determine the best times to call for the main survey.

2.4.3.3 Pilot Survey Response

We were unable to interview 23 households (15.2 percent of the potential sample).[23] Thus, 128 households were available to participate in the survey. Of these, 31 were ineligible, either because they were not owner-occupied or because the residents had not painted in the past five years. That left 97 households that were available *and* eligible. Of these, 43 (44 percent) provided useful survey data and 54 refused. The 43 useful responses comprised 28.5 percent of the original potential sample.

Responding households were in 30 counties and 11 air basins. A chi-square test showed that the distribution of basins among the responding households was not significantly different from that of the pilot potential sample ($X^2 = 8.189$, d.f. = 10, critical $X^2 = 18.31$). About half the responding residences were in urban areas (in 13 standard metropolitan statistical areas) and half were rural.

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[22] Copies of the notification letters are in Appendix A.

[23] The "unable to interview" category included 15 households that never answered the telephone, 7 numbers for disconnected parties or fax machines, and 1 household where no English was spoken.

2.4.3.4 Evaluation of the Pilot Survey

Telephone Script

The telephone script worked quite well. None of the contacts appeared to have difficulty understanding the questions or providing answers. However, ARB staff recommended that we change the order of some of the questions.

Number of Calls

Because our goal was to obtain a 90-percent response rate, we set no limit on the number of attempts[24] to contact households. Instead, we tried to find out how many calls would be necessary to obtain a response. For the households that answered the telephone, the distribution of the number of attempts was essentially the same whether the person provided data, refused to participate, or was ineligible. It took an average of three calls to resolve each household's status. An average of 11 calls were made to homeowners who never answered the telephone.

Time of Successful Contact

One of the objectives of the pilot survey was to determine when would be the best time to call the households. There was no significant difference in the distributions for calls yielding survey data, calls in which homeowners refused to participate, and calls that determined that a household was ineligible. Contacts were made from 8:38 a.m. to 7:10 p.m. Four time intervals appeared to be "best" for making contact: 11:00 to 11:30 a.m., 1 p.m. to 2 p.m., 4:00 to 4:30 p.m., and 5 p.m. to 7 p.m.

Effect of Notification Letters and Reward Offers

To evaluate the efficacy of providing notification letters and/or offering grocery certificates, we defined a desirable outcome as an eligible homeowner providing survey data. To be included in the analysis, a homeowner had to be contacted and be eligible for the survey. The two possible outcomes were then "provided data" or "refused." The overall probability of obtaining survey data from a contacted, eligible household was 0.44. One way of examining the results is to see what combinations of letter and reward resulted in a higher success rate. Offering a reward or *not* sending a letter resulting in higher positive response fractions than overall (0.52 and 0.48, respectively). The highest positive response fraction was for those who were offered a reward *and* were not sent a notification letter.

It is important, however, to determine the statistical significance of these results. A chi-square test of the outcomes shows that there was *no significant difference* (at the 95-percent confidence level) between actual and observed numbers of the positive responses among the four categories ($X^2 = 2.169$, d.f. = 1, $p < 0.14$, critical $X^2 = 3.841$). In addition, the confidence intervals about all of the response proportions were quite large. For example, the 95-percent confidence limits around the positive response fraction for the

[24] Note that "attempts" for the household pilot survey included cases in which no one answered the telephone. For the OEM coating users survey, no-answer calls were not included as "attempts."

reward plus the letter was [0.398, 0.802]. This may be compared with the confidence interval for the overall positive response rate [0.249, 0.638].

2.4.3.5 Implications and Changes for the Main Survey

After ARB staff reviewed the pilot survey report, it was decided to make several changes to the survey procedures and the telephone script. In addition to changing the order of some of the questions, the most important revisions were as follows:

- After obtaining data on temporal patterns and weather effects, we would eliminate from the survey those households that had not used solvent-based paints in the past five years.

- Respondents would be asked to estimate how much paint thinner and cleanup solvent they had *used* (as contrasted with purchased) in the past five years.

We also decided to:

- Concentrate the telephone calls in the most propitious time intervals, i.e. 11:00 to 11:30 a.m., 1 p.m. to 2 p.m., 4:00 to 4:30 p.m., and 5 p.m. to 7 p.m.;

- Not send notification letters or offer rewards; and

- Limit the number of telephone call attempts to four

2.4.4 Selection of the Main Survey Potential Sample

The potential sample for the main survey was the 4,025 California owner-occupied residences described in Section 2.4.2, minus the 128 homes contacted in the pilot survey and minus the 8 households for which the telephone was disconnected or no English was spoken. This left 3,889 residences for the main survey.

2.4.5 Survey Instruments

All telephone callers were required to follow, word for word, a single telephone script.[25] The general format of the script was patterned after one used by Wilson et al. (1991) for a microenvironmental air toxics exposure and monitoring study. Questions were numbered so that, at various junctures, the caller could be instructed where in the script to continue, given the response to the latest question. The purpose of the first nine questions was to determine whether the person answering the telephone was "qualified" to participate. To qualify, one had to meet the following criteria:

- Be over 18 years old;
- Live in the residence that was called;
- Be, or live with, the owner(s) of the residence; and

- Have done house painting (indoors or outdoors) at his or her present home or at another home within the last five years

Homeowners were asked what type of residence best described the home (e.g., detached single-family, duplex, etc.). It was believed that this information could prove useful in statistical analyses of the survey data.

The next group of questions (11 through 14) asked about the *last* time that the person did any painting. Data sought included the season, part of week (weekday or weekend), and time of day. Questions 15 through 18 concerned *future* painting activities; homeowners were asked about how they would alter their painting behavior on hot or cold days or in inclement weather. Question 19 asked whether the homeowner used solvent-based paints. If the answer was "no," then the interview was concluded. If "yes," then we asked the amount and type of thinning and cleaning solvents and what percentage thereof was used for thinning.

2.4.6 Survey Database Management System

Homeowner names, addresses and telephone numbers were copied from the InfoUSA.com, Inc. database to a Microsoft Access™ database designed specifically for this project. A unique identification number ("HHID") was assigned to each household. Other tables were set up to track the status of each household in the survey and to store response data. The database also included forms for data entry and various queries to examine the tables and summarize results. The survey data entry form was divided into numbered sections that corresponded to the numbered questions in the telephone script.

2.4.7 Full Survey Telephoning

Each day, telephone callers were given a list of names and telephone numbers of 200 to 400 randomly selected homeowners that had not yet been surveyed or eliminated. While they talked on the telephone, callers used Access forms to update the survey status of the household, and to enter data obtained from the homeowners.

Most of the calls were made during the time intervals decided upon after the pilot survey. (See Section 2.4.3.5.).

2.4.8 Survey Data Processing and Calculations

The same data processing and calculation methods that were described in Section 2.2.9 for the OEM coating user survey were used for the commercial painters survey.

2.4.9 Survey Quality Assurance/Quality Control

We used the same quality assurance/quality control procedures as were described for the OEM coatings users survey. (See Section 2.2.10.)

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[25] A copy of the script is in Appendix A.

2.5 DEVELOPMENT OF SOLVENT USE RATES AND EMISSION FACTORS

A major objective of this project was to develop improved emission factors for OEM coatings, and for the solvents that are associated with OEM and architectural coatings. In addition, we were to use survey results to verify or modify a long-used, but poorly documented assumption that paint thinning and cleanup solvents are used at the rate of one pint per gallon of oil-based architectural coating (Velasco and Goonan, 1998; Delao, 2003).

2.5.1 TOG, ROG and Regulatory VOC Content of OEM Coatings

OEM coating manufacturers provided information on the material and regulatory volatile organic compound (VOC) content of their products. The ROG was assumed equal to the reported VOC value, after conversion to pounds per gallon (lb/gal) of coating. In most cases, the "VOC" excluded exempt solvents such as acetone. To obtain values for TOG, it was necessary to add the exempt solvent(s) back in. Let WP_e be the weight percent of exempt solvents, and let ρ_c be the density of the coating. The mass of exempt compound(s) per gallon of coating is then $C_e = \rho_c WP_e/100$. We added this value to the ROG to obtain TOG. For example, let VOC = 3.36 g/L, ρ_c = 8.38 lb/gal and acetone = 11 percent by weight of coating. Then:

$$\begin{aligned} ROG &= (3.36\ g/L)(3.785\ L/gal)/453.6\ g/lb) \\ &= 0.0280\ lb/gal \\ C_e &= (8.38\ lb/gal)(11/100) = 0.922\ lb/gal \\ TOG &= 0.0280 + 0.922 = 0.950\ lb/gal \end{aligned}$$

For each coating category (marine, metal furniture, etc.), we calculated weighted mean TOG, ROG and regulatory VOC values, using the sales volumes of the reported coatings as the weights. Let EF_{ij} be the emission factor for product j of coating category i. Let V_{ij} be the annual sales (in gallons) for that product. Then the emission factor for the coating category, EF_i, is:

$$EF_i = \frac{(\sum_j V_{ij}EF_{ij})}{(\sum_j V_{ij})} \qquad [2\text{-}2]$$

Note that, because so few responses were received, we did not attempt to calculate confidence intervals about the weighted means.

2.5.2 TOG and ROG per Gallon of Thinning and Cleanup Solvent

For the thinning and cleanups solvents used in conjunction with OEM coatings and architectural coatings, we calculated weighted mean values of TOG and ROG per gallon of solvent material, the weights being the reported volumes of solvent used. A Shapiro-

Wilk test of the survey responses[26] was used to determine whether the survey data were from a normal distribution. If the data were found to be normal or nearly normal, we calculated the variance of the weighted mean (x_w) from (AGI, Undated):

$$\text{Var}(x_w) = \sigma^2/b \quad [2\text{-}3]$$

where

$$b = (\Sigma w_i)^2/\Sigma w_i^2 \quad [2\text{-}4]$$

The sample standard deviation was calculated as:

$$s_w = [\text{Var}(x_w)]^{1/2} \quad [2\text{-}5]$$

Because the half-width of a 90-percent confidence interval is proportional to $s_w/n^{1/2}$, it can be shown that

$$CI = x_w \pm 1.645\, s_w/n^{1/2} \quad [2\text{-}6]$$

Where there were fewer than five data points or the data were not normally distributed, we used bootstrap sampling (see Section 2.3.9) to calculate 90-percent confidence intervals.

2.5.3 Ounces of Solvent Used Per Gallon of Architectural Coating

The current ARB area source methodology for architectural coatings (Delao, 2003) assumes that paint cleanup and thinning solvents associated with solvent-based architectural coatings are used at the rate of one pint per gallon of *solvent-based* coating (emphasis added). At the beginning of the project, ARB staff requested that we use survey data to determine the accuracy of this assumption.

For this analysis, we used the results of the commercial painters survey. Separate ratios were calculated for:

- Thinners for solvent-based coatings;
- Cleanup solvents for solvent- and water-based coatings; and
- Additives for water-based coatings

2.5.3.1 Thinners for Solvent-Based Coatings

For thinners, we used three types of information reported by the commercial painters, First, we used values of ounces per gallon (oz/gal) that were reported directly by the survey respondents; these use rates varied from 0 to 64 oz/gal. For painting firms that did not report use ratios, but did use thinners for solvent-based coatings, we calculated oz/gal ratios by dividing reported solvent use by reported solvent-based coating use. Finally, we

[26] For sample sizes of five or greater.

included cases in which painters reported adding no thinner to their solvent-based paints. The thinner use rate was calculated as a weighted average for each solvent type (mineral spirits, lacquer thinner, etc.). The weights were gallons of solvent-based coatings associated with each use of thinner. Confidence intervals about the means were determined by bootstrap sampling.

2.5.3.2 Cleanup Solvents for Solvent- and Water-Based Coatings

As will be discussed in Section 12, we suspected that at least some survey respondents reported total cleanup solvent use without breaking it down between coating bases. To minimize errors in reporting, we determined ratios of total cleanup solvent use to total coating use, regardless of coating base. The use rate for each survey response was defined as the ratio between cleanup solvent volume (in ounces) and the reported coating use (in gallons). We pooled the responses for all solvent types (mineral spirits, lacquer thinner, etc.). The calculated use rates varied from 0 to 51 oz/gal. We used reported gallons of coatings as weights in calculating the average oz/gal for the cleanup solvents. The confidence intervals about the mean was determined by the method presented in Section 2.5.2.

2.5.3.3 Additives to Water-Based Coatings

We also calculated an average use rate for VOC-containing additives to water-based coatings. Our sample consisted of all the responses that reported use of water-based coatings. The use rate varied from 0 to 76.8 oz/gal. We used gallons of water-based coatings as weights in calculating the average oz/gal for the additives. Confidence intervals about the means were determined by bootstrap sampling.

2.6 EMISSION INVENTORY CONSTRUCTION

TOG and ROG emissions were calculated for the following sources:

- Thinners, cleanup solvents and additives for architectural coatings applied by commercial painters;
- Thinners and cleanup solvents for architectural coatings applied by households;
- Thinners, cleanup solvents and additives for OEM coatings in selected industries; and
- Solvents in selected OEM coatings

In all cases, emissions were calculated by multiplying emission factors (in pounds per gallon of solvent or coating, as appropriate) by the volume used. *All emission values presented in this report are of uncontrolled emissions.*

2.6.1 Solvents Associated With Commercial Painting

2.6.1.1 Estimation of Statewide Volumes

Statewide volumes of thinning and cleanup solvents associated with solvent-based coatings, and additive and cleanup solvents associated with water-based coatings, were calculated by multiplying the use rates described in Section 2.5.3 by the appropriate total volumes of AIM coatings used by commercial painters. It was therefore necessary to determine the commercial painters' portion of the total AIM coatings reported in the ARB's 2001 Survey.

The ARB's 2001 survey estimated solvent-based and water-based AIM coating use to be 16,906,211 and 81,548,961 gallons per year, respectively. The first step in determining the portion used by commercial painters was to identify coating categories used exclusively by the professionals. As seen in Table 2-12, we believe that 16 coating categories meet this criterion. After subtracting the coatings corresponding to the 16 categories, we are left with 9,135,638 gallons of solvent-based coatings and 74,401,293 gallons of water-based coatings that must be divided between commercial painters and households. To do this we followed the ARB's assumption, based upon a recent market survey (Detiveaux and Bangert, 2001), that commercial painters use about 70 percent of architectural coatings. Commercial painters' total use therefore equals their use of commercial-only coating categories plus 70 percent of the rest. As seen in Table 2-12, our estimates of solvent- and water-based coatings by commercial painters are 14,165,520 and 59,228,573 gallons per year, respectively.

2.6.1.2 Apportionment to Counties, Air Basins and Air Pollution Control Districts

Statewide commercial painting solvent volumes and emissions were allocated to counties, air basins and air pollution control districts in proportion to the numbers of painters in each geographic unit.

Allocation of Painters From State to County

The number of painters in California and in subdivisions thereof was estimated from two data sources. First, the California Employment Development Department (EDD) periodically surveys and projects the number of people in various occupations. Using surveys of employers, the EDD estimates employment for a base year and then forecasts future employment on the basis of growth and technology (EDD, 2003a, 2003b). The main advantage of the EDD data is that they are organized by occupation, rather than industry; for a painting firm, only the painters would be counted. Fortunately for our study, 2001 is the most recent base year, i.e. its values are derived from survey data instead of projections. However, there are two problems with these data. First, for 33 of the state's 58 counties, data are aggregated into multi-county "consortiums" (EDD, 2000), so that individual counties' values cannot be determined. Second, the EDD occupational data are

Table 2-12

CALCULATION OF COMMERCIAL PAINTERS' AND HOMEOWNERS' SHARES OF AIM COATING USE

Total Statewide Sales	Solvent-Base	Water-Base	Total
	16,906,211	81,548,961	98,455,172
COMMERCIAL ONLY			
Bituminous Roof	1,608,033	1,637,364	3,245,397
Bituminous Roof Primer	69,993	100,527	170,520
Bond Breakers		93,896	93,896
Concrete Curing Compounds	32,925	660,024	692,949
Dry Fog	243,047	216,709	459,756
Fire Retardant - Opaque	PD[a]	26,690	PD[a]
Form Release Compounds	223,634	32,090	255,724
Graphic Arts	13,667	12,722	26,389
High Temperature	18,621		18,621
Industrial Maintenance	4,126,134	613,946	4,740,080
Metallic Pigmented	513,541	112,402	625,943
Pre-Treatment Wash Primer	4,188	71,154	75,342
Roof	89,448	1,047,906	1,137,354
Swimming Pool	12,399	9,687	22,086
Swimming Pool Repair and Maintenance	15,266		15,266
Traffic Marking	799,677	2,539,241	3,338,918
Total Commercial Only	7,770,573	7,147,668	14,918,241
Remaining	9,135,638	74,401,293	83,536,931
Commercial Painter Portion	6,394,947	52,080,905	58,475,852
Household Portion	2,740,691	22,320,388	25,061,079
Total Commercial Painter	**14,165,520**	**59,228,573**	**73,394,093**
Total Household	**2,740,691**	**22,320,388**	**25,061,079**

[a]PD = Protected data (fewer then three companies reported sales); coating categories with PD were not used coatings used exclusively by commercial painters.

only for workers covered by the Unemployment Insurance Program; they do not include self-employed individuals. Self-employed painters had to be considered separately. For each county or consortium, we obtained the numbers of employed persons in two categories:

- Painters, Construction & Maintenance
- Painting, Coating, & Decorating Workers

We disaggregated the consortium data by assuming that the EDD employment figures were proportional to employment estimates in the U.S. Census Bureau's *County Business Patterns* (U.S. Census, 2003a) in North American Industry Classification System (NAICS) number 235 ("Special Trade Contractors"). Let P_i be the number of painters in the ith consortium, and let p_j be the employment in NAICS 235 in the jth county. Then the number of painters in the jth county is:

$$P_j = P_i (p_j / \Sigma p_j) \qquad [2\text{-}7]$$

To estimate the number of self-employed painters in each county, we used the U.S. Census Bureau's "Nonemployer Statistics 2001" database (U.S. Census, 2003b). This database summarizes the number of establishments and sales or receipts of companies with no paid employees. Most of these are sole proprietors or partnerships. Data are available by year, and by state and county.

For each county in California, we obtained the number of establishments in NAICS 2352 ("Painting and Wall Covering Contractors"). We assumed that each establishment had one active painter. This is consistent with our finding that 30 percent of the responding firms had only one painter. (See Section 5.2.2). We needed a special procedure for counties with fewer than 10 self-employed painters, for which only a code was reported (Alpine, Colusa, Del Norte, Modoc, Sierra and Trinity). For this case, we subtracted the number of self-employed painters in the counties for which data were reported from the number of self-employed painters for the state as a whole. The difference was 27. This number was apportioned to the six aforementioned counties in proportion to the each county's number of firms in NAICS code 235, as was done above.

The total number of painters per county was estimated by adding the employed painters to the nonemployer values. Table 2-13 shows the results. We estimate that there are about 62,000 commercial painters in the state.

Table 2-13

ESTIMATED NUMBERS OF PAINTERS IN CALIFORNIA, BY COUNTY

County	Self-Employed Painters	Employed Painters	Total	County	Self-Employed Painters	Employed Painters	Total
Alameda	680	2,390	3,070	Orange	2,066	4,220	6,286
Alpine	1	2	3	Placer	187	427	614
Amador	24	18	42	Plumas	14	18	32
Butte	98	180	278	Riverside	870	1,770	2,640
Calaveras	29	32	61	Sacramento	636	1,330	1,966
Colusa	4	6	10	San Benito	24	130	154
Contra Costa	517	1,920	2,437	San Bernardino	812	1,780	2,592
Del Norte	7	7	14	San Diego	1,465	4,630	6,095
El Dorado	111	226	337	San Francisco	625	1,380	2,005
Fresno	219	720	939	San Joaquin	181	600	781
Glenn	14	17	31	San Luis Obispo	218	240	458
Humboldt	81	100	181	San Mateo	492	1,020	1,512
Imperial	25	50	75	Santa Barbara	352	510	862
Inyo	10	24	34	Santa Clara	682	2,540	3,222
Kern	239	430	669	Santa Cruz	199	200	399
Kings	27	90	117	Shasta	88	100	188
Lake	31	54	85	Sierra	3	5	8
Lassen	10	7	17	Siskiyou	27	24	51
Los Angeles	7,041	9,880	16,921	Solano	162	330	492
Madera	46	70	116	Sonoma	335	680	1,015
Marin	262	600	862	Stanislaus	165	550	715
Mariposa	16	6	22	Sutter	19	32	51
Mendocino	53	70	123	Tehama	18	21	39
Merced	61	130	191	Trinity	8	8	16
Modoc	5	5	10	Tulare	107	140	247
Mono	11	46	57	Tuolumne	53	45	98
Monterey	231	440	671	Ventura	486	720	1,206
Napa	111	240	351	Yolo	58	330	388
Nevada	116	170	286	Yuba	14	33	47
				State	20,446	41,743	62,189

Allocation of Painters From Counties to Air Basins

We used air basin maps to identify the air basin(s) corresponding to each county. Eight counties (El Dorado, Kern, Los Angeles, Placer, Riverside, San Bernardino, Solano and Sonoma) are in two or more air basins. Using data published in *The 2003 California Almanac of Emissions and Air Quality* (Alexis et al., 2003), we determined the fraction of each county's total population that was in each air basin. We then allocated the county's painters to each basin in proportion to its fractional population in that basin. Table 2-14 shows the resulting distribution of painters by air basin.

Table 2-14

DISTRIBUTION OF COMMERCIAL PAINTERS BY AIR BASIN

Basin Code	Basin Name	Estimated Painters in 2001
GBV	Great Basin Valleys	94
LC	Lake County	85
LT	Lake Tahoe	103
MC	Mountain Counties	867
MD	Mojave Desert	1,264
NC	North Coast	459
NCC	North Central Coast	1,224
NEP	Northeast Plateau	78
SC	South Coast	26,736
SCC	South Central Coast	2,526
SD	San Diego	6,095
SF	San Francisco Bay Area	14,690
SJV	San Joaquin Valley	3,662
SS	Salton Sea	628
SV	Sacramento Valley	3,678
	Total	62,189

Allocation to Air Pollution Control Districts

Emissions were to be calculated for five air pollution control districts. (See Section 2.8.) For a given district, emissions were summed for each county in the district. All of each county's emissions were included, even if the county was in other districts.

2.6.2 Solvents Associated With Painting by Households

As part of the survey of owner-occupied households, we estimated the use of various categories of solvents (mineral spirits, lacquer thinner, etc.) in gallons per year, by county and air basin. As we did not collect information on the TOG or ROG content of the sol-

vents used by homeowners, we used emission factors (in pounds per gallon) for the solvents reported by commercial painters to calculate emissions from painting by households.

2.6.3 Solvents Associated With Use of OEM Coatings

As discussed in Section 4, we determined the statewide volumes of thinners and cleanup solvents associated with the use of OEM coatings, for three three-digit SIC codes. We also developed TOG and ROG emission factors (in lb/gal) for the same categories of solvents. The volumes were multiplied by the emission factors to obtain statewide emission estimates. Given the small survey response, we did not believe it to be useful to allocate these emissions to counties or air basins.

2.6.4 Solvents in Selected OEM Coatings

Uncontrolled emission factors were obtained for several categories of OEM coatings. (See Section 7.1.1.) These were multiplied by our estimates of statewide coating volumes that were developed in Section 3.1.

2.7 DEVELOPMENT OF SPECIATION PROFILES

Speciation profiles are tables showing the mass fraction or percent of each constituent in a material. This definition was used to develop speciation profiles for the solvents associated with use of OEM and architectural coatings.

Most of the information we obtained on the composition of solvents, including solvent formulations, came from material safety data sheets (MSDSs). Because the purpose of an MSDS is to alert the user of the product to the product's hazards, the composition data usually are reported only for hazardous ingredients. For a given solvent formulation, the reported species percentages often did not sum to 100. Therefore not all the species profiles that we developed account for all the ingredients in the solvents and coatings.

Let C_{ij} be the concentration (as a weight percent) of species i in formulation j. Let V_j be the reported use of the formulation (in gallons or pounds). Then the weighted average percentage of species i in the formulation is:

$$\text{Wt Pct} = (\Sigma V_j C_{ij})/(\Sigma V_j) \qquad [2\text{-}8]$$

2.8 IDENTIFICATION AND APPLICATION OF SPATIAL SURROGATES

The objective of this task was to develop a set of surrogates for allocating county-wide emissions to geographic subdivisions of specific counties, including 2-kilometer (2-km) grid squares. Surrogates are quantities, other than emissions, whose spatial distribution may be related accurately to the spatial distribution of emissions. They are used because it is frequently far easier to obtain values for a surrogate, such as the population of a census tract, than it is to determine the emissions of every single source within the geographic subdivision. Frequently used surrogates include population, employment in spe-

cific sectors, housing units, and automobile registration. These surrogates are often used to allocate national emissions to a state and/or statewide emissions to counties. In the present project, we were to allocate emissions from counties to smaller subdivisions. Surrogates were to be developed for counties in the air pollution control districts listed in Table 2-15.[27]

After reviewing the results of the surveys conducted for this project, we decided to develop spatial allocation methods for emissions from solvents associated with the application of architectural coatings (Rogozen, 2003b). Activities of commercial painters and homeowners were to be considered separately. Chambers Group, Inc. (CGI) was given the tasks of identifying appropriate surrogates, evaluating graphical information system (GIS) data sets that would be useful in applying the surrogates, and formulating a detailed implementation plan.

2.8.1 Criteria for Evaluating Data Sets

Before choosing among different GIS data sets, evaluation criteria were set. These criteria addressed, in no specific order: cost, resolution, completion, accuracy, source, currency, and consistency between neighboring counties and within air basins. Each of these criteria is addressed below, along with its specific importance to this project.

Cost. The cost of data sets varies greatly among sources. It can be applied on a cost per item such as parcels, cost per data set, or cost per amount of data such as by megabyte or CD. Costs were noted for planning purposes but were not a limiting factor.

Resolution. Resolution of data sets also varies greatly among sources. The resolution of a data set will be limited by its ability to be used at the largest scale – the 2 km by 2 km grid cell. Data sets which address a smaller scale (larger area) per internal unit become intrinsically less useful as they depart from the ideal scale.

Completion. This criterion is often misconstrued to mean that a data set is unusable if it is incomplete. In this type of analysis, there is the potential that a partially complete data set at a much higher resolution could be merged with a more complete data set at a lower resolution to create an overall better product, despite its inconsistency. Also two incomplete data sets from two sources within one county may be combined to cover a majority or entirety of the county in question. Completion is described by two methods, percent complete and area(s) complete. The completion type was recorded for each data set identified.

[27] If a county was partially in one of the listed air pollution control districts, all of the county was included in the study.

Table 2-15

AIR POLLUTION CONTROL DISTRICTS FOR WHICH SPATIAL SURROGATES WERE TO BE DEVELOPED

Air Pollution Control District	Counties
South Coast Air Quality Management District	Los Angeles Orange Riverside San Bernardino
San Diego County Air Pollution Control District	San Diego
Bay Area Air Quality Management District	Alameda Contra Costa Marin Napa San Francisco San Mateo Santa Clara Solano Sonoma
San Joaquin Valley Unified Air Pollution Control District	Fresno Kern Kings Madera Merced San Joaquin Stanislaus Tulare
Sacramento Metropolitan Air Quality Management District	Sacramento

Accuracy. This criterion looks at the chance that an error was made in translating the data from their original source to the current digital format. It is cumulative with the inherent errors of the original source and any translations or data format changes which may have occurred. Accuracy is a combined representation of the method of creation, source of data, and skill of creator or translator. The highest accuracy available is preferred.

Source. The reputation of a particular data source and its known history in providing accurate and complete data sets was considered. Reputable sources lend to the credibility of any study. Disreputable sources shall not be entertained.

Currency. GIS data sets represent a subject over an area at a specific time. It is important to limit the spread of time between data sources to ensure that false conclusions are not made. Additionally, it is important to utilize data generated at or close to the time of the surveys in order to accurately represent the conditions at the time of the survey.

Consistency. The consistency of all other criteria as they are applied to the various counties within each air basin ensures reliable results. It can be very easy to gather a highly diversified conglomeration of data. However, the inconsistencies within disparate data sets can quickly become a significant weight in the analysis and can easily skew answers inappropriately. The highest level of consistency within the available data sets was sought.

2.8.2 Identification and Evaluation of Data Sets

Based upon CGI's research of data availability, data sources of data were divided into five categories: federal, state, multi-county, county, and city. The criteria described in the previous section were used to evaluate each data set.

2.8.2.1 Federal

The following Federal Government agencies were identified and contacted regarding the availability of their GIS formatted data or data which might be useful and easily converted to GIS:

- Bureau of the Census
- Environmental Protection Agency
- Army Corps of Engineers
- Geological Survey
- Internal Revenue Service
- Department of Homeland Security

Two of these agencies have readily accessible data, two have data protected by privacy regulations, and two have no data that would be of any use to this study. The U.S. Bureau of the Census (USBC) has provided the largest quantity of data that may be of use in this investigation. The data set of interest from the USBC is the California compilation of all data from the year 2000 Census. Limiting factors of this data set are resolution, consistency, and accuracy. The resolution of this data set is the Block, which varies in area and often is larger than the desired 2 by 2 km grid. Both consistency and accuracy contain minor imperfections resulting from the nature of the compilation of data that makes up the Census.

- The US Geological Survey (USGS) has abundant data resources for the State of California. These vary in standard resolution from 1:24,000, to 1:100,000, to 1:250,000 and much smaller (higher ratios). There are no

known data sets of interest from the USGS that cannot be obtained from other sources.

- The Department of Homeland Security and the Internal Revenue Service both utilize GIS data sets internally but do not publish their data due to privacy regulations. It is unlikely that data would be obtainable at a resolution greater than that provided by the US Census. If the data were obtainable, it is unlikely that they would be of much use for this investigation.

- The US Army Corps of Engineers publishes only data specific to the areas over which it has jurisdiction or to areas in which it is planning to perform some public work. It is unlikely that any of their data will be of assistance.

- The US Environmental Protection Agency also publishes GIS data, but it is environmental, specific to the nature of the organization. It is unlikely that any of their data will be of assistance.

2.8.2.2 State of California

The State of California gathers GIS data from all of its departments and makes then available on the Internet in one location, the California Spatial Information Library (CASIL). This includes data sets carried over from the former Teale Data Center. The full data holdings include administrative districting; cultural geography, including Census 2000 data for California; physical geography, including hydrologic resources, facilities and locations, and transportation networks. Data gathered in this site are provided to the public free of charge. Unfortunately, significant research into the vast data holdings of this site and its entire set of connecting links has provided little result for this study beyond the availability of USCB 2000 Census data.

2.8.2.3 Multi-County Organizations

While multi-County organizations (e.g., the Southern California Association of Governments) all have and utilize GIS, the data are rarely created at the association level. Instead, multi-county databases are usually compilations of donations from the member county governments. When data are created at this level, they are highly generalized across the counties and do not provide enough detail to contribute to this study.

2.8.2.4 Counties

The counties identified in the five air pollution control districts were polled regarding their GIS data holdings. Of the 23 counties, 21 use GIS data in their planning, engineering, or assessing departments. Of those with GIS data, all had incorporated the USCB 2000 Census data into their databases. Most receive a continuous feed of data from the assessor and/or the planning departments updating their data on a regular basis. Unfortunately these data updates are generally lot value, survey date and associated data, and reg-

istered owner name and contact information. Very little cultural data such as employment or profession is obtained at this level of government.

2.8.2.5 Cities

CGI identified and polled two cities per county (where possible) regarding their GIS services and data holdings. Of the 45 cities identified, 39 have been identified as having a GIS of some level. The level of development for the cities with GIS is widely disparate. Likewise the amount and quality of city level GIS data is also varies significantly. Where city data have been developed in detail, they are often provided to the county. Once again, the data relevant to city operation does not lend itself well to this study.

3.0

RESULTS OF THE OEM COATING MANUFACTURERS RESEARCH

3.1 ESTIMATION OF TOTAL OEM COATING USE IN CALIFORNIA

A major objective of this investigation was to determine the amounts of industrial coatings used in California. This information was to be obtained through a survey of manufacturers of coatings used in original equipment manufacturing (OEM). As will be discussed later, we suspected that the total volume of OEM coatings reported by the manufacturers who responded to our survey was significantly lower than the actual statewide value. We therefore used another approach to estimate the statewide volume. This estimate was then used to gauge the completeness of our survey, and to calculate statewide emissions.

The U.S. Census Bureau has published total U.S. quantities and values of shipments of paint and allied products by manufacturers in various years, including 2001 (U.S. Census, 2002). The data are organized into four product classes: architectural coatings, product coatings (OEM), special-purpose coatings, and miscellaneous allied paint products. Within each of these main classes, the coatings have been further classified by coating type and/or type of application.

Our first step was to identify all the coating products in *Paint and Allied Products: 2001* that would be considered "OEM coatings" for our study. For each product, we then identified all the North American Industrial Classification System (NAICS) codes for Industries where the product would likely be used. For each NAICS code, we found U.S. and California numbers of establishments and employment from the 2001 editions of *County Business Patterns* (U.S. Census, 2003c, 2003d). Finally, for each product, we calculated California coatings volume from each of the following formulas:

$$V_{CA} = aV_{US}\,(E_{CA}/E_{US})$$

$$V_{CA} = aV_{US}\,(F_{CA}/F_{US})$$

In these equations, V, E, and F and coating volume, employment and number of facilities, respectively, and the subscripts CA and US refer to California and national values, respectively. Note that each formula has an adjustment factor, "a," which is used by the Census Bureau to make these values consistent with other economic data that it collects. For OEM coatings, a = 0.993.

Table 3-1 shows the coating products that we considered to be OEM coatings, their national shipment volumes, and the NAICS codes for the industries in which these coatings were assumed to be used. We have also assigned each coating product with a letter code. Table 3-2 shows the apportionment calculations. For the "Other Not Classified" category, we had no NAICS codes for the apportionment. Instead, we used the California/U.S. ratio of employment (or number of facilities) for the other categories combined, and applied it to this one.

Table 3-1

2001 U.S. SHIPMENTS OF OEM COATINGS, WITH ASSUMED NAICS CODES OF OEM COATING USERS

Key	OEM Category	U.S. Product Shipments (10^6 Gallons)	NAICS Codes for Apportionment
A	Automobile, Light Truck, Van and SUV	45.409	336
B	Automobile Parts	4.134	336
C	Heavy Duty Truck, Bus and Recreational Vehicle	12.064	336
D	Other Transportation Equipment, Inc. Aircraft and Railroad	12.426	336
E	Appliance, Heating Equipment, and Air Conditioners	7.987	333
F	Wood Furniture, Cabinet, and Fixture	42.871	337
G	Wood and Composition Board Flat Stock	11.287	321
H	Metal Building Product, Inc. Aluminum Extrusions and Siding	36.825	331316, 3323
I	Container and Closure	38.443	32192, 32213, 327213, 332439
J	Machinery and Equipment, Including Road Building Equipment and Farm Implements	19.584	333
K	Nonwood Furniture and Fixture, Including Business Equipment	56.160	337124, 337125, 337127, 337214, 337215, 339111
L	Paper, Paper Board, Film and Foil	13.834	32213, 322215, 32222 326112, 326113, 332999
M	Electrical Insulating	1.925	335929, 335931
N	Other Not Classified	39.947	See Text
	Total	342.896	

Table 3-2

APPORTIONMENT OF U.S. OEM COATING SHIPMENTS TO CALIFORNIA ON THE BASIS OF EMPLOYMENT OR NUMBERS OF FACILITIES

Key	U.S. Product Shipments (1000 Gallons)	NAICS Codes for Apportionment	Employment Basis			Facility Basis			Mean CA Volume
			US	CA	10^6 Gallons	US	CA	10^6 Gallons	10^6 Gallons
A	45.409	336	1,753,445	153,221	3.940	12,627	1,633	5.831	4.886
B	4.134	336	1,753,445	153,221	0.359	12,627	1,633	0.531	0.445
C	12.064	336	1,753,445	153,221	1.047	12,627	1,633	1.549	1.298
D	12.426	336	1,753,445	153,221	1.078	12,627	1,633	1.596	1.337
E	7.987	333	1,332,854	101,784	0.606	28,922	2,903	0.796	0.701
F	42.871	337	619,197	71,678	4.928	20,593	2,800	5.788	5.358
G	11.287	321	557,507	40,652	0.817	17,289	1,294	0.839	0.828
H	36.825	331316, 3323	447,469	49,830	4.072	12,577	1,471	4.277	4.174
I	38.443	32192, 32213, 327213, 332439	132,209	12,040	3.476	3,670	353	3.672	3.574
J	19.584	333	1,332,854	101,784	1.485	28,922	2,903	1.952	1.719
K	56.160	337124, 337125, 337127, 337214, 337215, 339111	202,050	26,667	7.360	4,259	691	9.048	8.204
L	13.834	32213, 322215, 32222 326112, 326113, 332999	283,422	17,618	0.854	5,479	640	1.605	1.229
M	1.925	335929, 335931	96,094	8,721	0.173	871	118	0.259	0.216
N	39.947	See Text			3.982			4.977	4.479
Totals	342.896		12,017,436	1,043,658		173,090	19,705		
California Apportioned Volumes					**34.178**			**42.719**	**38.449**
California Percent of U.S. Totals					10.0%			12.5%	11.2%

As seen in Table 3-1, about 343 million gallons of OEM coatings were shipped in 2001 by U.S. coating manufacturers. If one uses employment as the basis for apportionment, then California's share is 10.0 percent, or about 34,178,000 gallons per year. If one uses the number of establishments as the basis, then California's share is 12.5 percent, or about 42,719,000 gallons. The means of these values, which were used in emission calculations, are 11.2 percent and 38,449,000 gallons.

3.2 RESULTS OF THE SURVEY OF OEM COATING MANUFACTURERS

3.2.1 Survey Response

Tables 3-3 and 3-4 summarize the responses to the main survey and the prioritized OEM coating manufacturer surveys, which were described in Section 2.1. Only 18 firms (4 percent of those eligible) responded to the main survey, and 6 firms responded to the prioritized survey.

Table 3-3

RESPONSE TO THE MAIN OEM COATING MANUFACTURERS SURVEY

TOTAL SURVEY PACKAGES MAILED			729
Ineligible for the Survey			287
	Not an OEM Coating Manufacturer	121	
	Relocated or Out of Business	87	
	No California Sales	79	
ADJUSTED POTENTIAL SAMPLE			442
	Explicitly Refused to Respond	77	
	Did Not Respond	347	
	Responded With Data	18	

Table 3-4

RESPONSE TO THE PRIORITIZED OEM COATING MANUFACTURERS SURVEY

Outcome	Number	Percent
Explicitly Refused to Provide Data	11	45.8
Did Not Respond	7	29.2
Responded With Data	6	25.0
Total	24	100.0

3.2.2 Summary of Reported Data

Respondents to the survey reported sales of 162 coating products in the categories of interest. The total sales volume reported was 2,583,569 gallons. This accounts for only 6.0 or 7.6 percent of the statewide volume estimated in the previous section. Table 3-5 shows the volumes reported, by solvent category and coating base. In our sample, water-based coatings comprised 77.5 percent of the sales volume. However, in two coatings categories (can and coil, and wood furniture and fixtures), solvent-based coatings predominated. Table 3-6 shows the number of products reported for each of the coating categories and coating bases. The best response was for metal parts and products coatings, for which we obtained information on 56 products.

Table 3-5

CALIFORNIA OEM COATING SALES REPORTED BY SURVEY RESPONDENTS

Coating Category	Gallons of Coatings Sales Reported		
	Solvent-Based	Water-Based	Total
Marine	4,399	214,675	219,074
Paper	0	0	0
Fabric	0	0	0
Metal Furniture and Fixtures	0	16,971	16,971
Can and Coil	92,143	47,979	140,122
Metal Parts and Products (Except Furniture)	213,566	1,184,346	1,397,912
Wood furniture and Fixtures	66,544	20,659	87,203
Pleasure Craft	0	0	0
Other	204,531	517,756	722,287
Total	581,183	2,002,386	2,583,569

Table 3-6

NUMBERS OF COATING PRODUCTS REPORTED, BY COATING CATEGORY AND COATING BASE

Coating Category	Number of Products Reported		
	Solvent-Based	Water-Based	Total
Marine	3	2	5
Paper	0	0	0
Fabric	0	0	0
Metal Furniture and Fixture	0	3	3
Can and Coil	9	15	24
Metal Parts and Products (Except Furniture)	37	19	56
Wood Furniture and Fixtures	27	6	33
Pleasure Craft	0	0	0
Other	27	14	41
Totals	103	59	162

As seen in Table 3-7, relatively small sales volumes per coating manufacturer were sold to California. Annual volumes for half the products were less than 1,000 gallons per year, and volumes for about 77 percent of the products were less than 5,000 gallons per year. From our survey, then, it appears that there may be many small suppliers serving niche markets. We may not have identified all of these. In addition, the smaller suppliers may have been less able to commit their resources to filling out the questionnaire forms.

Section 7.1 contains information on the TOG and ROG content of the reported OEM coatings, which were used in emission calculations. We also asked coating manufacturers to report the "regulatory VOC" content of their products, since this value is used to determine whether a coating complies with regulations that limit solvent content. Table 3-8 shows the weighted average regulatory VOC for each combination of coating type and base, the weights being the corresponding California volumes.

Table 3-7

NUMBERS OF OEM COATING PRODUCTS REPORTED, BY SALES VOLUME CLASS

Gallons of Product Sold	No. of Products in Volume Range
≤ 1,000	84
1,000 - 5,000	40
5,000 - 10,000	18
10,000 - 50,000	12
50,000 - 100,000	3
> 100,000	5
Total	162

Table 3-8

VOLUME-WEIGHTED REGULATORY VOC CONTENT OF REPORTED OEM COATINGS, BY COATING CATEGORY

Type of Coating	Coating Base	Regulatory VOC Pounds per Gallon
Marine	Solvent	2.82
	Water	2.29
Metal Furniture and Fixtures	Water	1.91
Can and Coil	Solvent	2.91
	Water	1.84
Metal Parts and Products	Solvent	2.52
	Water	2.31
Wood Furniture and Fixtures	Solvent	4.47
	Water	1.78
Other	Solvent	2.96
	Water	1.99

4.0

RESULTS OF THE OEM COATING USERS SURVEY

4.1 SURVEY RESPONSE

Table 4-1 characterizes the response to the survey of OEM coating users. We received direct responses from 1,488 firms, or 30.7 percent of the firms that were not presumably out of business. The adjusted potential sample, which we define as the number of mailings (or initial faxes) minus the number of firms that were out of business or are not manufacturing plants or job shops, was 4,197 companies. We received at least some "useful data" from 798 firms, or 19.0 percent of the adjusted potential sample. In this case, "useful data" includes either information about a facility's solvent use and temporal patterns or information that the facility is a manufacturer but does not apply any OEM coatings.

Table 4-1

RESPONSES TO THE OEM COATING USERS SURVEY

TOTAL SURVEY PACKAGES MAILED OR FAXED			5,038
Presumed Out of Business			197
	Returned by US Postal Service	93	
	Telephone Disconnected	104	
AVAILABLE FOR SURVEY			4,841
Ineligible for the Survey			644
	Claimed to be Out of Business	59	
	Administrative/Sales Office Only	50	
	Not a Manufacturing Plant	535	
ADJUSTED POTENTIAL SAMPLE			4,197
	Explicitly Refused to Respond	46	
	Responded With Data	66	
	Manufacturer-No Coating	732	
	Did Not Respond	3,353	

Figure 4-1 shows the modes of response for the 1,488 responding firms. A little over half of the responses were obtained by follow-up telephone calls.

4.2 CHARACTERISTICS OF THE SURVEY SAMPLE

For this survey, the "sample" was defined, for a given SIC code, as facilities that provided data on paint, solvent use, temporal patterns and/or weather influences; plus facilities that reported that they were manufacturers or job shops but that they did not apply any coatings to manufactured parts. We excluded facilities that were not manufacturers

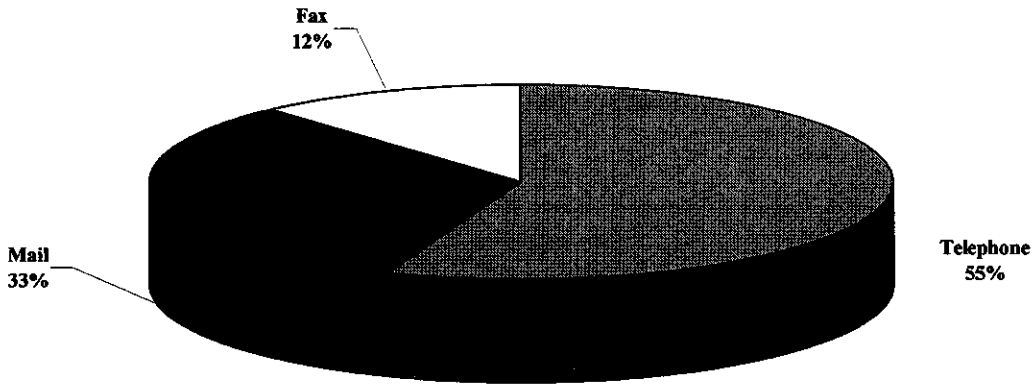

Figure 4-1. Modes of Response for OEM Coating Users Survey.

or job shops; were out of business; or that explicitly refused to respond. Table 4-2 shows the distribution of the survey sample by two-digit SIC code. The response rate per SIC code ranged from 7.7 (for Textile Mill Products) to 52.6 (for Household Furniture).

After a discussion with the ARB contract manager (Vincent, 2003a), we decided to focus our detailed analysis of survey results on the three SIC codes for which we had the highest number of data responses: SIC 34 (Fabricated Metal Products), SIC 35 (Industrial and Commercial Machinery and Computer Equipment), and SIC 37 (Transportation Equipment). For the rest of this report, we will refer to the data for these three two-digit SIC codes as "the selected sample." We also analyzed, for two-digit SIC codes outside the selected sample, reported thinner use, temporal patterns and weather effects.

4.3 COATING AND SOLVENT USE RESULTS

4.3.1 Reported Coating Use

Although this survey focused on use of thinning and cleanup solvents, we also asked OEM coating users to report their volumes of solvent- and water-based coatings. The reported values are useful for comparison with the findings of the survey of OEM coating manufacturers, and for developing solvent-per-gallon-coating emission factors.

Table 4-2

SAMPLE AND ADJUSTED SAMPLE, BY TWO-DIGIT SIC CODE

SIC Code	Description	Provided Data	OEM Manufacturer/ No Coating	Total Sample	Potential Sample	Percent of Potential Sample
20	Food and Kindred Products	0	11	11	37	29.7
22	Textile Mill Products	1	1	2	26	7.7
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials	1	14	15	101	14.9
24	Lumber and Wood Products, Except Furniture	4	32	36	167	21.6
25	Household Furniture	4	86	90	171	52.6
26	Paper and Allied Products	2	10	12	62	19.4
30	Rubber and Miscellaneous Plastics Products	2	47	49	232	21.1
32	Stone, Clay, Glass, and Concrete Products	0	11	11	75	14.7
33	Primary Metal Industries	1	3	4	32	12.5
34	Fabricated Metal Products	23	136	159	830	19.2
35	Industrial and Commercial Machinery and Computer Equipment	11	246	257	1,389	18.5
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment	5	72	77	579	13.3
37	Transportation Equipment	9	28	37	251	14.7
38	Measuring, Analyzing and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks	1	24	25	139	18.0
39	Miscellaneous Manufacturing Industries	2	11	13	106	12.3
	Totals	66	732	798	4,197	19.0

Table 4-3

VOLUMES OF COATINGS REPORTED BY OEM COATING USERS SURVEY RESPONDENTS, BY TWO-DIGIT SIC CODE

SIC Code	Description	Firms Reporting	Annual Coating Use (Gallons)		
			Solvent-Based	Water-Based	Totals
20	Food and Kindred Products	0	0	0	0
22	Textile Mill Products	1	133,335	0	133,335
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials	1	40	0	40
24	Lumber and Wood Products, Except Furniture	4	3,106	181	3,287
25	Household Furniture	3	2,875	100	2,975
26	Paper and Allied Products	1	48	12	60
30	Rubber and Miscellaneous Plastics Products	1	40	10	50
32	Stone, Clay, Glass, and Concrete Products	0	0	0	0
33	Primary Metal Industries	1	0	7,117	7,117
34	Fabricated Metal Products	15	1,840	1,001,759	1,003,599
35	Industrial and Commercial Machinery and Computer Equipment	11	1,693	1,220	2,913
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment	3	834	100	934
37	Transportation Equipment	8	11,711	1,456	13,168
38	Measuring, Analyzing and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks	1	0	95	95
39	Miscellaneous Manufacturing Industries	2	7,325.0	0	7,325
	Totals	52	162,847	1,012,050	1,174,898

Table 4-3 summarizes the data provided by the survey respondents. We did not attempt to project the results to any SIC code or geographic area. The facilities in our survey reported use of about 1,175,000 gallons of coating, or about 2.8 to 3.4 percent of our estimate of total OEM coating use in the state (see Section 3.1).

For all the respondents, about 14 percent of the reported coating use was of solvent-based coatings. For fabricated metal products (SIC 34), however, water-based coatings comprised 99.8 percent of the reported volume. For individual manufacturing facilities, the percentage of solvent-based coatings ranged from 0 to 100, with a mean of 64.

4.3.2 Reported Solvent Use

Table 4-4 shows the volumes of each type of thinning solvent reported by facilities in SIC codes 34, 35 and 37, and in all the other SIC codes combined. For the selected sample, acetone accounted for most of the solvent use. For the survey as a whole, toluene and naphtha predominate. However, all the reported toluene and naphtha are from one facility.

Table 4-4

THINNER USE REPORTED BY THE SELECTED SAMPLE AND ALL OTHER SIC CODES COMBINED

Type of Solvent	Gallons Reported					
	Selected Sample				Other SICs	Total for All SICs
	SIC Code			Total for Selected Sample		
	34	35	37			
Mineral Spirits	28	0	0	28	0	28
Lacquer Thinner	0	26	0	26	22	48
Acetone	205	366	1,038	1,609	883	2,492
Denatured Alcohol	0	0	0	0	1	1
Isopropyl Alcohol	13	0	0	13	0	13
Naphtha	0	0	0	0	7,592	7,592
Toluene	1	0	0	1	72,535	72,536
Xylenes	0	0	0	0	271	271
MEK	3	0	0	3	1,045	1,048
Other	0	6	0	6	4,745	4,751
Totals	249	398	1,038	1,685	87,093	88,778

Table 4-5 shows the reported volumes of cleanup solvents for the selected sample. Solvent volumes associated with solvent- and water-based coating use were combined. For SIC codes 34 and 37, acetone use predominated, while for SIC code 35, lacquer thinner had the highest reported volume.

Table 4-5

CLEANUP SOLVENT USE REPORTED BY THE SELECTED SAMPLE

Type of Solvent	Gallons Reported			
	SIC Code			Totals
	34	35	37	
Mineral Spirits	8	96	145	249
Lacquer Thinner	145	190	0	335
Acetone	476	115	5,630	6,221
Denatured Alcohol	7	0	7	14
Toluene	1	40	0	41
Xylene	68	0	0	68
Other	20	1	487	508
Totals	725	441	6,269	7,434

4.3.3 Ounces of Solvent Per Gallon of Coating

Use rates for thinners and cleanup solvents in the selected sample were calculated by dividing reported total use by reported total corresponding volume of coatings. For thinners, only the volume of solvent-based coatings was used. For cleanup solvents, the volume of solvents associated with both solvent- and water-based coatings was divided by the sum of the volumes of the two coating bases. In all cases, the calculations included only those responses for which solvent use and coating use were reported. Table 4-6 shows the results. The cleanup solvent use rate for SIC 37 appears somewhat high. One reason may be that at least three of the responding firms are fiberglass boat manufacturers, and may be using large amounts of acetone for cleaning fiberglass spray equipment, rather than coating equipment.

Table 4-6

OUNCES OF THINNING AND CLEANUP SOLVENT PER GALLON OF OEM COATING, FOR THE SELECTED SAMPLE

Solvent Type	Coating Base	Ounces per Gallon		
		SIC 34	SIC 35	SIC 37
Thinner	Solvent Only	17.32	30.11	11.34
Cleanup	Solvent and Water	19.79[a]	15.16	60.94

[a]Does not include one facility that reported 1 million gallons of coating use and no solvent use.

4.3.4 Projected Solvent Volumes

As will be discussed in Section 7.1.2, TOG and ROG emission factors were developed for several types of solvents associated with OEM coating use. These emission factors (see Table 7-6) do not distinguish between use of solvents for thinning or for cleanup. We therefore need an estimate of statewide use of each coating type in the three SIC codes.

Table 3-2 shows statewide OEM coating use by groups of NAICS codes. It was necessary, therefore, to determine which NAICS codes corresponded to the three SIC codes in the selected sample. We did this by reference to U.S. Census correspondence tables that are available on the Internet. Table 4-7 shows the California OEM coating use corresponding to each SIC code.

Table 4-7

ESTIMATED STATEWIDE OEM COATING USE IN SIC CODES 34, 35 AND 37

SIC Code	OEM Categories	Mean California Volume (10^6 Gal /Year)	
		Per Category	Total for SIC
34	Metal Building Products	4.174	7.749
	Containers and Closures	3.574	
35	Appliance, Heating Equipment, and Air Conditioners	0.701	2.419
	Machinery and Equipment, Including Road Building Equipment and Farm Implements	1.719	
37	Automobile, Light Truck, Van and SUV	4.886	7.966
	Automobile Parts	0.445	
	Heavy Duty Truck and Bus and Recreational Vehicle	1.298	
	Other Transportation Equipment, Including Aircraft and Railroad	1.337	

Next, we assumed that the coating base (solvent or water) was in the same proportions as reported by survey respondents. (See Table 4-3.) Finally, solvent use was estimated by using the use rates shown in Table 4-6. Table 4-8 shows the calculation. Largely because of the possibly anomalously high ounces-per-gallon ratio for cleanup solvents in SIC 37, the selected sample is estimated to use 6.2 million gallons per year of thinning and cleanup solvents. Given the uncertainty in the use rate for SIC 37, emissions were calculated only for SICs 34 and 35.

Table 4-8

ESTIMATED STATEWIDE USE OF THINNING AND CLEANUP SOLVENTS IN SIC CODES 34, 35 AND 37

SIC Code	34		35		37	
Total Annual Coating Use (10^6 Gal/Yr)	7.7486		2.4194		7.9657	
	Solvent-Based	Water-Based	Solvent-Based	Water-Based	Solvent-Based	Water-Based
Use Fraction	0.001833	0.998167	0.581188	0.41881	0.889392	0.11061
Annual Coating Use by Base (10^6 Gal/Yr)	0.01421	7.73439	1.40611	1.01327	7.08459	0.88107
Thinner Use (Gal/Yr)	1,922		330,765		627,920	
Cleanup Solvent Use (Gal/Yr)	1,198,136		286,538		3,792,136	
Total Solvent Use (Gal/Yr)	**1,200,059**		**617,303**		**4,420,056**	

4.4 TEMPORAL PATTERNS

4.4.1 Annual Distribution of Activity

Facilities were asked to report the percentage of their annual painting activity that occurred in each month. To calculate mean monthly percentages, we weighted each reported value for a given firm by that firm's total volume of coating use (solvent-borne plus water-borne). When all the survey data are included, annual activity is uniform. However, one facility accounted for 98 percent of the coating use; since it reported uniform annual activity, the result for the survey as a whole is clearly biased. Figure 4-2 shows the results of the analysis for the selected sample, including 90-percent confidence intervals about the mean, when data from the high-volume facility are omitted. The annual distribution of activity is then decidedly non-uniform. It is significantly higher than uniform in April, May, June and August, and significantly lower in September through February. Figure 4-3 shows the mean percentage of annual activity by season, for the selected sample.

Analysis of data for SIC codes other than 34, 35 and 37 showed uniform annual activity.

4.4.2 Weekday Vs Weekend

Facilities were asked whether they applied OEM coatings during the week, on Saturday, and/or on Sunday. The purpose of the question was to obtain data for estimating the percentage of weekly activity that occurs during each of the three time periods. Table 4-9 shows the results, by season, for the State. The activity for each reporting facility was weighted by the facility's total coating use, and data for the high-coating use firm were omitted. A significant number of firms apparently operate on a Monday through Saturday schedule, and none of the survey respondents reported activity on Sunday.[28]

[28] Except for the facility whose data were omitted.

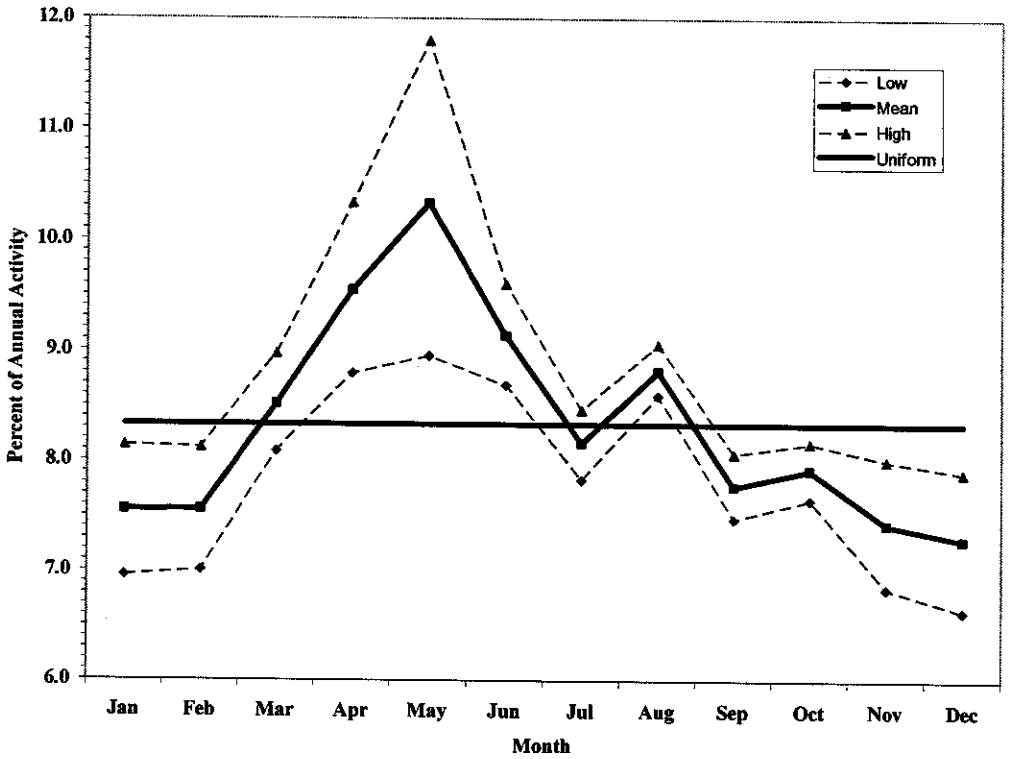

Figure 4-2. Mean and 90-Percent Confidence Intervals for Monthly Percentages of OEM Coating Activity, for the Selected Sample.[29]

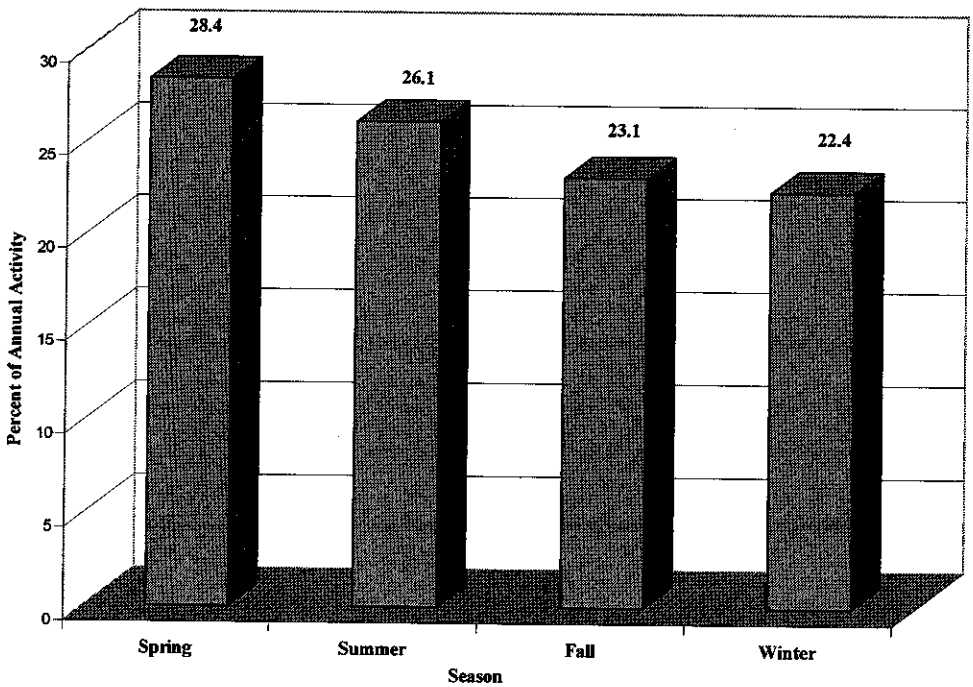

Figure 4-3. Mean Percentage of Annual OEM Coating Activity, by Season.

[29] Does not include data from one very high-volume facility with uniform annual activity.

Table 4-9

WEEKDAY VS WEEKEND DISTRIBUTION OF PAINTING ACTIVITY FOR THE SELECTED SAMPLE[a]

Season	Weekday	Saturday	Sunday
Spring	76.13	23.87	0.00
Summer	76.13	23.87	0.00
Fall	86.76	13.24	0.00
Winter	86.70	13.30	0.00

[a]Does not include data from one high-coating-use facility.

None of the responding facilities in the SIC codes other than 34, 35 or 37 reported painting activity on weekends.

4.4.3 Diurnal Patterns

We also asked facilities to report the hours of day when they apply paint and/or use cleanup solvents.[30] Figures 4-4 through 4-7 show the results statewide for each season, for the selected sample. Each facility's response was weighted by the sum of its solvent- and water-based coating use. The bars represent the percent of each day's activity that occurs during each hour. The patterns for the four seasons are very similar. All show a dip during the hour from noon to 1 p.m., presumably for a lunch break. The hour of maximum activity, in spring, summer and fall is 10 to 11 a.m.; in winter it is 1 to 2 p.m. The main hours of activity, for all seasons, are 6 a.m. to 6 p.m.

It is sometimes useful to normalize activity patterns to a common variable, so that different patterns may be compared on the same basis. Table 4-10 shows the hourly activity levels, by season, normalized to uniform hourly activity (4.167 percent per hour).

The diurnal activity patterns for the SIC codes other than 34, 35 and 37 were different, as seen in Table 4-11. Enough data for constructing diurnal profiles were available only for SIC 24, 25 and 36. All three of these SIC codes have shorter work days (5 or 9 hours) than the selected sample (12 hours).

[30] We also asked them to identify the hours when cleanup solvents were used, but very few did.

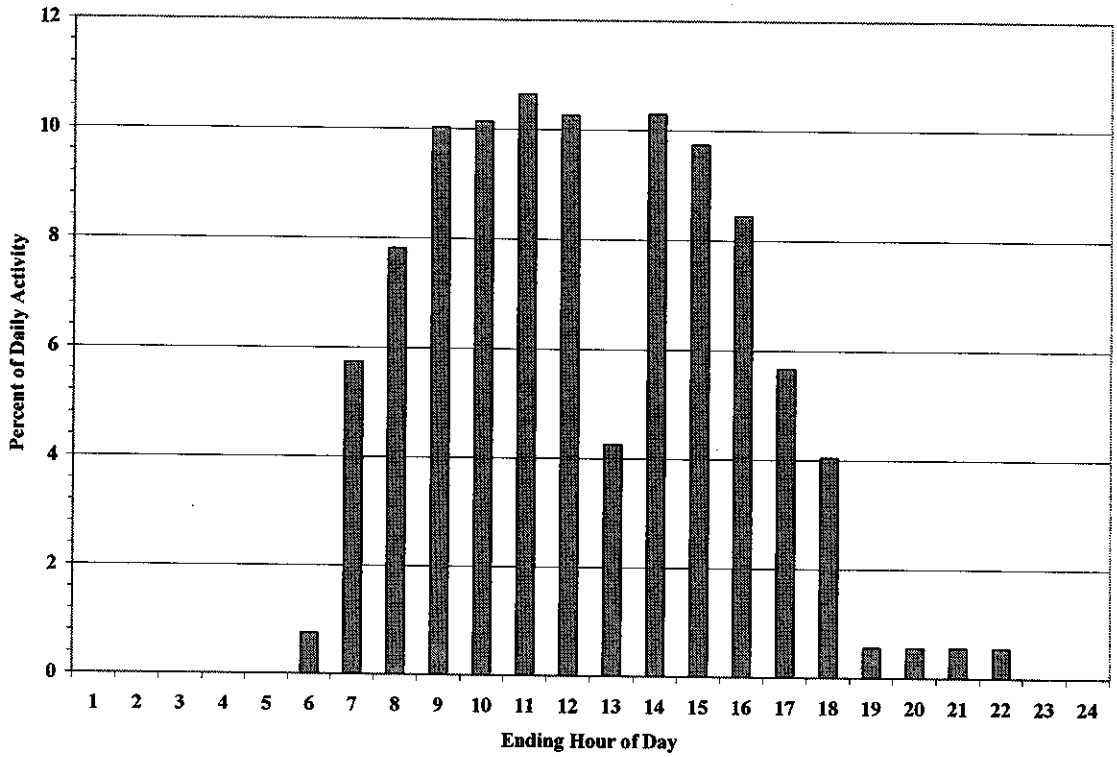

Figure 4-4. Diurnal Pattern of OEM Coating Activity for the Selected Sample: Spring.

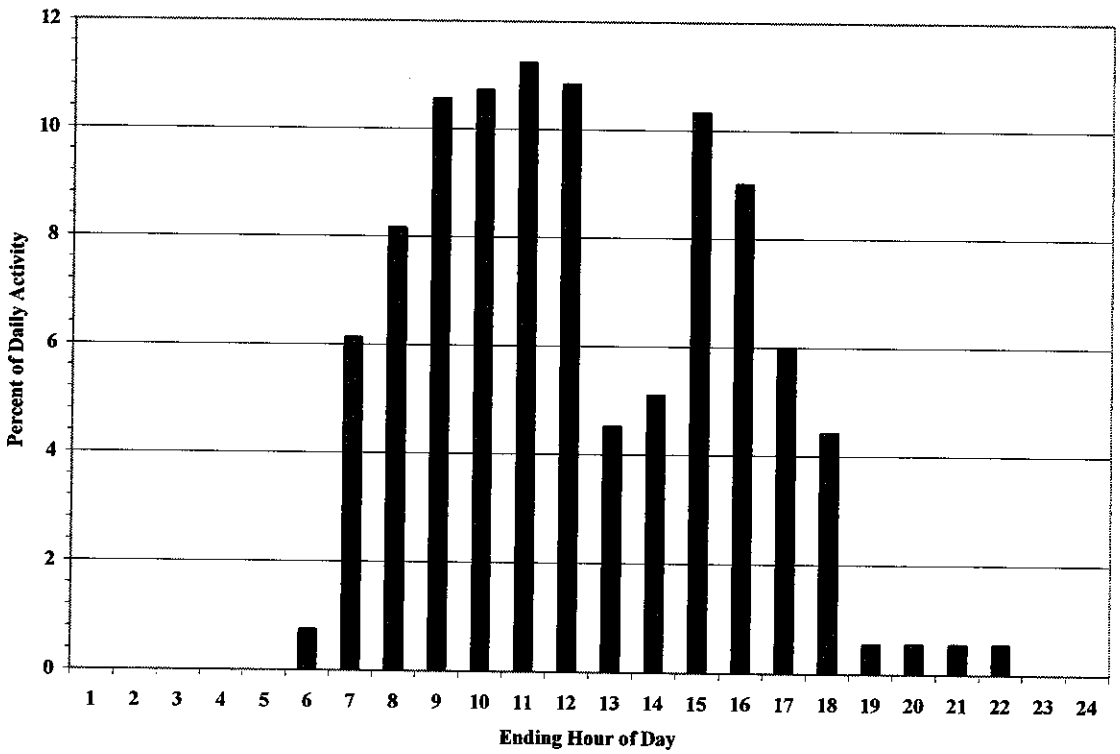

Figure 4-5. Diurnal Pattern of OEM Coating Activity for the Selected Sample: Summer.

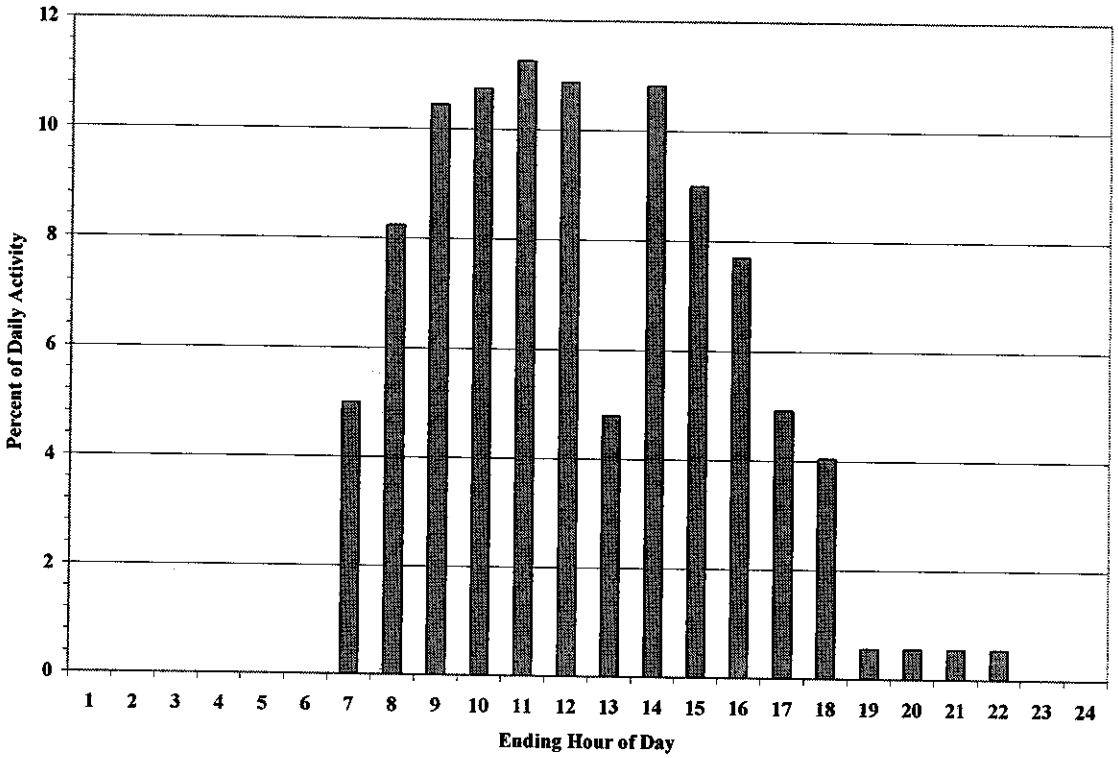

Figure 4-6. Diurnal Pattern of OEM Coating Activity for the Selected Sample: Fall.

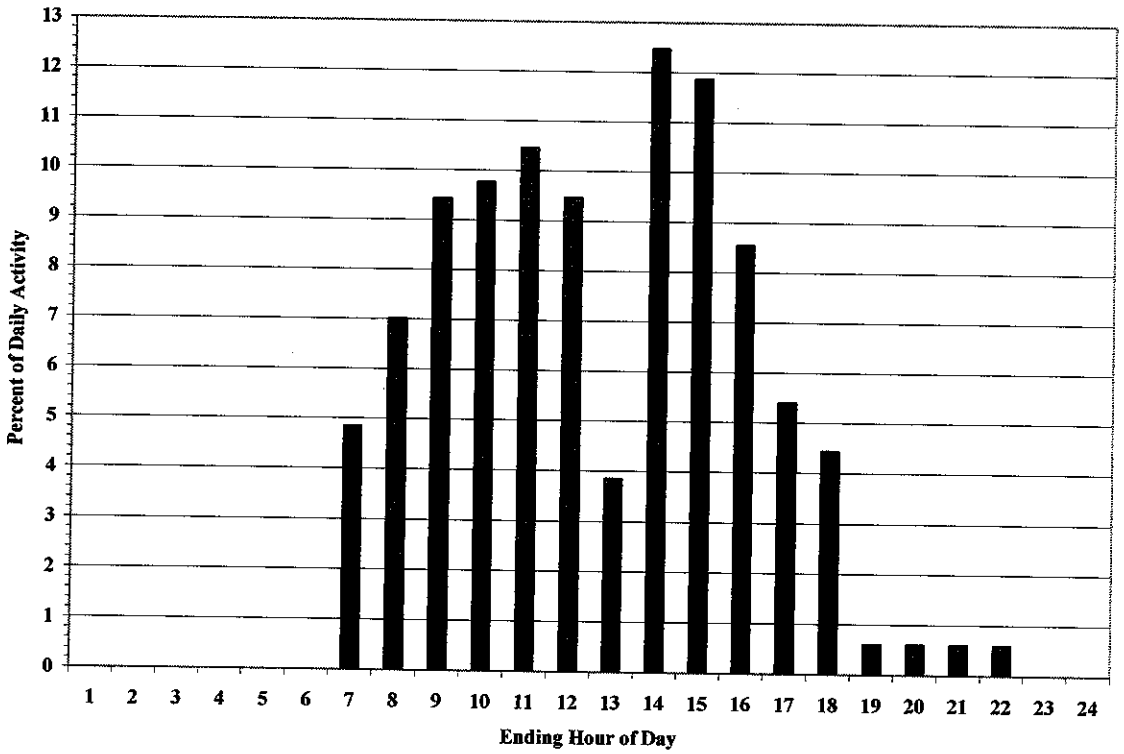

Figure 4-7. Diurnal Pattern of OEM Coating Activity for the Selected Sample: Winter.

Table 4-10

NORMALIZED HOURLY ACTIVITY LEVELS FOR THE SELECTED SAMPLE

Ending Hour	Spring	Summer	Fall	Winter
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0.18	0.18	0	0
7	1.38	1.47	1.20	1.16
8	1.88	1.96	1.98	1.68
9	2.41	2.53	2.51	2.26
10	2.43	2.57	2.58	2.34
11	2.55	2.70	2.70	2.51
12	2.46	2.60	2.61	2.27
13	1.02	1.08	1.15	0.93
14	2.47	1.22	2.60	2.99
15	2.34	2.48	2.16	2.85
16	2.03	2.16	1.85	2.05
17	1.36	1.44	1.18	1.30
18	0.97	1.06	0.97	1.07
19	0.13	0.13	0.13	0.15
20	0.13	0.13	0.13	0.15
21	0.13	0.13	0.13	0.15
22	0.13	0.13	0.13	0.14
23	0	0	0	0
24	0	0	0	0

Table 4-11

NORMALIZED HOURLY ACTIVITY LEVELS FOR OTHER SIC CODES

Ending Hour	SIC 24				SIC 25				SIC 36			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0.02	0.02	0.02	0.02	2.48	3.01	3.01	3.01	2.67	2.67	2.67	2.67
10	0.02	0.02	0.02	0.02	2.48	3.01	3.01	3.01	2.67	2.67	2.67	2.67
11	5.86	5.86	5.86	5.86	2.48	3.01	3.01	3.01	2.67	2.67	2.67	2.67
12	5.86	5.86	5.86	5.86	2.47	2.99	2.99	2.99	2.66	2.66	2.66	2.66
13	0.14	0.14	0.14	0.14	1.40	0	0	0	2.67	2.67	2.67	2.67
14	5.98	5.98	5.98	5.98	3.87	2.99	2.99	2.99	2.67	2.67	2.67	2.67
15	5.98	5.98	5.98	5.98	3.87	2.99	2.99	2.99	2.67	2.67	2.67	2.67
16	0.14	0.14	0.14	0.14	2.47	2.99	2.99	2.99	2.66	2.66	2.66	2.66
17	0	0	0	0	2.47	2.99	2.99	2.99	2.66	2.66	2.66	2.66
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0

4.5 WEATHER EFFECTS

Facilities were asked how unusually hot or cold weather, or rain or snow would affect their painting activity. For each condition, they were given the following choices, not all of which needed be mutually exclusive:

- Not paint on those days
- Use less or more thinner per gallon of paint than "normal"
- Use different thinners than on "normal" days
- Use different cleanup solvents than on "normal" days
- Paint earlier in the day
- Paint later in the day
- Paint as normal

"Hot" days were defined as those above 90°F, while "cold" days were defined as those below 40°F.

Table 4-12 shows the responses, by two-digit SIC code, for the case of unusually hot weather. Responses were weighted by total reported gallons of paint used (solvent- and water-based). It appears that hot weather elicits different responses for the three SIC codes. For SIC code 34, almost all the facilities would paint as normal. In contrast, fewer than half the facilities in SIC codes 35 and 37 would paint as normal; their main alternative responses would be to use more thinner (SIC 35) and use a different thinner (SIC 37). Facilities in SIC 37 would also paint earlier in the day.

Table 4-13 shows the responses for the case of unusually cold weather. Again, facilities in SIC code 34 would paint as they normally do. Even lower percentages of facilities in SIC codes 35 and 37 would paint as normal in cold weather than was reported for hot weather. In SIC 35, the main reaction would be to use less thinner; some facilities would not paint at all, use more thinner, or paint later in the day. In SIC 37, almost 20 percent would not paint at all. The main response to cold weather in this SIC code would be to use a different thinner; some would also paint later in the day.

As seen in Table 4-14, the responses for the case of inclement weather are similar for SIC codes 34 and 35. Over 70 percent of the facilities would paint as normal. The next most reported option would be not to paint. Some facilities also reported using less thinner and painting earlier in the day. For SIC 35, only about 24 percent of the facilities would paint as normal in inclement weather; the largest response would be to use a different thinner, while some would paint later in the day.

A similar analysis was performed for all the SIC codes outside the selected sample. For hot and inclement weather, essentially all the reporting facilities said that they would paint as normal. For cold weather, about 83 percent would paint as normal, and about 17 percent would paint later in the day.

Table 4-12

EFFECT OF UNUSUALLY HOT WEATHER ON OEM COATING ACTIVITY

SIC Code	n	Percent of Responses							
		Not Paint	Use Less Thinner	Use More Thinner	Use Different Thinner	Use Different Cleanup Solvent	Paint Earlier in Day	Paint Later in Day	Paint as Normal
34	14	0.0	0.7	0.0	0.0	0.0	0.9	0.0	98.4
35	9	0.0	6.9	51.5	0.0	0.0	6.9	0.0	41.6
37	8	0.5	0.0	0.0	57.0	0.0	13.3	0.0	29.2

Table 4-13

EFFECT OF UNUSUALLY COLD WEATHER ON OEM COATING ACTIVITY

SIC Code	n	Percent of Responses							
		Not Paint	Use Less Thinner	Use More Thinner	Use Different Thinner	Use Different Cleanup Solvent	Paint Earlier in Day	Paint Later in Day	Paint as Normal
34	12	0.0	0.7	0.0	0.0	0.0	0.0	0.0	99.3
35	8	5.7	51.6	6.9	0.0	0.0	0.0	1.7	34.2
37	8	19.5	0.0	0.0	57.0	0.0	0.0	13.5	10.0

5.0

RESULTS OF THE COMMERCIAL PAINTERS SURVEY

5.1 SURVEY RESPONSE

Table 5-1 characterizes the response to the survey of commercial painters. We received direct responses from 560 firms, or 32.0 percent of the firms that were not presumably out of business. The adjusted potential sample, which we define as the number of mailings minus the number of firms that were out of business or, for one reason or another, do not apply AIM coatings, was 1,655 companies. We received at least some useful data from 245 painters, or 14.8 percent of the adjusted potential sample.

A relatively high percentage of the firms (17.9 percent of the original mailing) either reported that they were out of business or were presumed to be because their mailings were returned by the U.S. Postal Service or their telephone numbers were disconnected. One reason for this was that the mailing list was obtained in April 2001 and may have become outdated by Spring, 2003, when the follow-up work was completed.

Table 5-1

RESPONSES TO THE COMMERCIAL PAINTERS SURVEY

TOTAL SURVEY PACKAGES MAILED			2,055
Presumed Out of Business			303
	Returned by US Postal Service	86	
	Telephone Disconnected	217	
AVAILABLE FOR SURVEY			1,752
Ineligible for the Survey			97
	Claimed to be Out of Business	65	
	Administrative/Sales Office Only	3	
	Does Not Perform AIM Coating Services	29	
ADJUSTED POTENTIAL SAMPLE			1,655
	Explicitly Refused to Respond	218	
	Responded With Data	245	
	Did Not Respond	1,192	

Figure 5-1 shows the modes of response for all the responding firms and for those who provided data. In both cases, the great majority of responses were obtained by follow-up telephone calls.

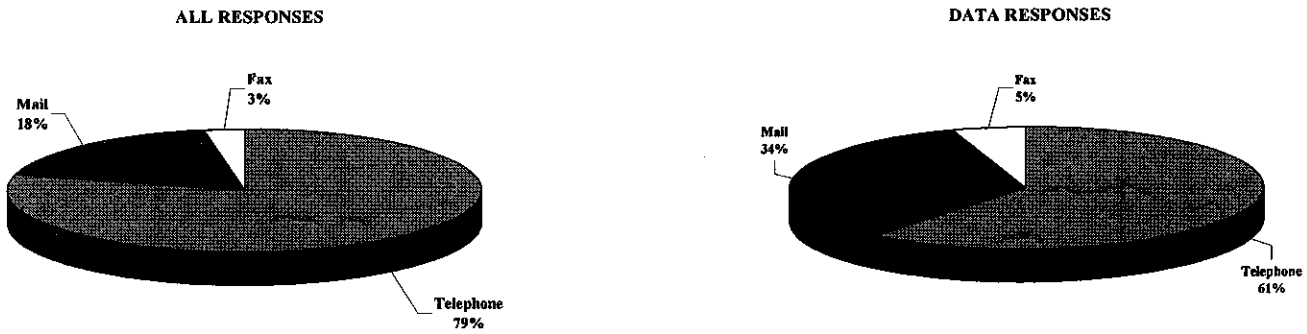

Figure 5-1. Response Mode for All Responses Combined and for Data Responses Alone.

5.2 CHARACTERISTICS OF THE SURVEY SAMPLE

5.2.1 Geographic Distribution

At least two data responses were received from each of the fifteen air basins covered by this survey. Table 5-2 shows the number of data responses from each air basin surveyed. In the table, the sampling frame for each basin was estimated by multiplying the pre-survey count of painting firms times the ratio of the adjusted potential sample to the potential sample for the survey. (See Table 5-1.) The last column shows, for each basin, the survey sample's percentage of the estimated total number of commercial painting firms for that basin. This value ranges from 3.0 percent (South Coast Air Basin) to 30.8 percent (Great Basin Valleys). A chi test of the response shows that the sample is not randomly distributed by basin ($X^2 = 130.978$, d.f. = 14, $p << 0.001$). Table 5-3 shows the distribution of the sampling frame and the sample by county.

5.2.2 Painters Per Commercial Painting Firm

Figure 5-2 shows the cumulative distribution of the reported number of painters in the field per commercial painting firm. About 30 percent of the responding firms had only one employee, and 64 percent have three or fewer. The maximum number of painters reported was 100.

Table 5-2

DISTRIBUTION OF THE SURVEY SAMPLE BY AIR BASIN

Air Basin	Initial Sampling Frame	Adjusted Sampling Frame	Survey Sample	Percent of Sampling Frame
Great Basin Valleys	16	13	4	30.8
Lake County	15	12	2	16.7
Lake Tahoe	19	15	2	13.3
Mojave Desert	61	49	5	10.2
Mountain Counties	126	101	10	9.9
North Central Coast	132	106	17	16.0
North Coast	54	43	7	16.3
Northeast Plateau	14	11	2	18.2
Sacramento Valley	372	300	29	9.7
Salton Sea	62	50	7	14.0
San Diego	295	238	30	12.6
SF Bay Area	1,041	838	28	3.3
San Joaquin Valley	344	277	32	11.6
South Central Coast	235	189	28	14.8
South Coast	1,764	1,421	42	3.0
Total	**4,550**	**3,663**	**245**	**6.7**

Table 5-3

DISTRIBUTION OF THE SURVEY SAMPLE BY COUNTY

County	Initial Samping Frame	Adjusted Sampling Frame	Survey Sample	County	Initial Sampling Frame	Adjusted Sampling Frame	Survey Sample
Alameda	159	128	5	Orange	593	478	9
Alpine	4	3	1	Placer	58	47	5
Amador	6	5	1	Plumas	7	6	1
Butte	36	29	5	Riverside	181	146	7
Calaveras	14	11	2	Sacramento	175	141	14
Colusa	3	2	0	San Benito	5	4	1
Contra Costa	140	113	4	San Bernardino	181	146	10
Del Norte	2	2	1	San Diego	295	238	30
El Dorado	34	27	4	San Francisco	127	102	2
Fresno	105	85	6	San Joaquin	63	51	7
Glenn	2	2	0	San Luis Obispo	56	45	10
Humboldt	23	19	4	San Mateo	146	118	1
Imperial	6	5	1	Santa Barbara	77	62	10
Inyo	5	4	1	Santa Clara	248	200	9
Kern	57	46	7	Santa Cruz	59	48	7
Kings	9	7	1	Shasta	29	23	2
Lake	15	12	2	Sierra	0	0	0
Lassen	6	5	2	Siskiyou	7	6	0
Los Angeles	918	739	25	Solano	42	34	5
Madera	8	6	1	Sonoma	107	86	4
Marin	102	82	4	Stanislaus	60	48	6
Mariposa	3	2	0	Sutter	10	8	0
Mendocino	18	14	1	Tehama	8	6	0
Merced	24	19	3	Trinity	1	1	0
Modoc	1	1	0	Tulare	26	21	3
Mono	7	6	2	Tuolumne	22	18	0
Monterey	68	55	9	Ventura	102	82	8
Napa	22	18	0	Yolo	23	19	0
Nevada	39	31	2	Yuba	6	5	0
				Totals	**4,550**	**3667**	**245**

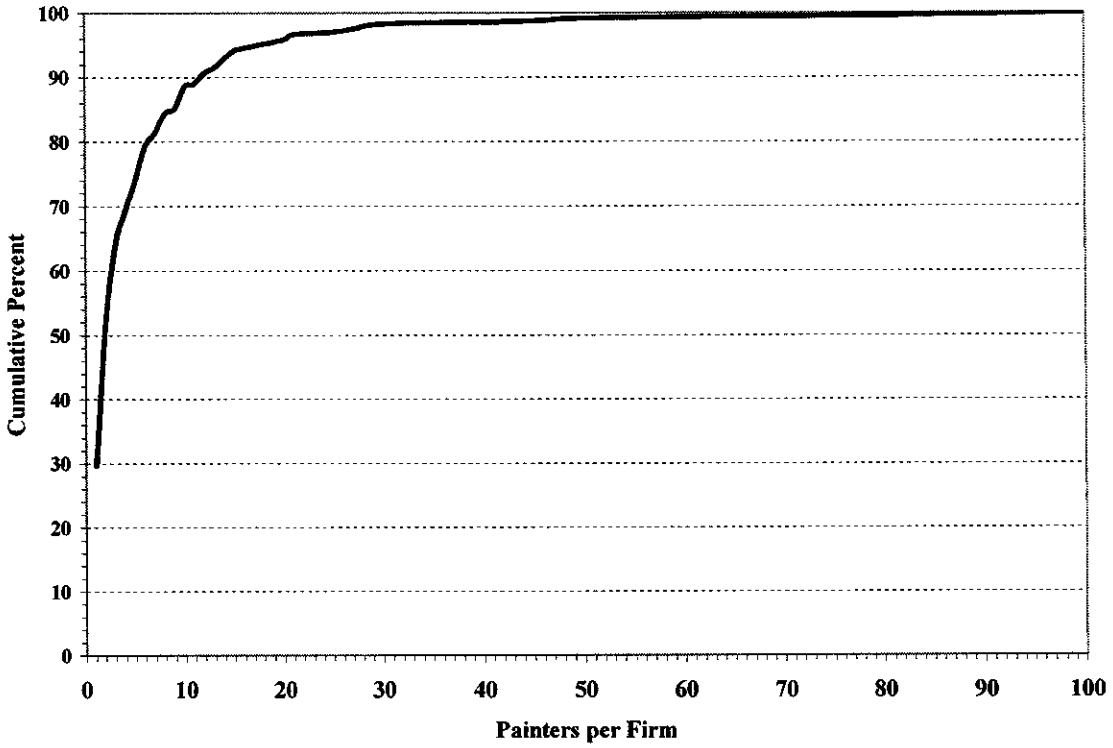

Figure 5-2. Cumulative Distribution of Painters per Firm.

5.3 COATING AND SOLVENT USE RESULTS

5.3.1 Reported Coating Use

Although the purpose of this survey was not to estimate the use of architectural and industrial maintenance (AIM) coatings *per se*, we needed information on coating use to calculate the solvent use factors to be developed later in the project. Table 5-4 summarizes the data provided by the survey respondents. The painters in our survey reported use of about 784,000 gallons of coating, or about 1.1 percent of the statewide total of 73.4 million gallons estimated from the ARB's 2001 architectural coatings survey (ARB, 2003).[31]

For the state as a whole, about 9 percent of the reported coatings were solvent-based. This value is lower than the 17 percent determined from the 2001 ARB survey. Only in the Lake County Air Basin was the volume of solvent-based coating greater than that of the water-based coatings. For individual painting firms, the percentage of solvent-based coatings ranged from 0 to 100, with a mean of 20.4.

[31] The 73.4 million gallons represents the portion of the ARB survey total that is associated with professional paint contractors.

Table 5-4

AIM COATING USE REPORTED BY SURVEY RESPONDENTS, BY AIR BASIN

Air Basin	Gallons Coating Reported			Solvent-Based As % of Total
	Solvent-Based	Water-Based	Total	
Great Basin Valleys	402	3,650	4,052	9.9
Lake County	192	150	342	56.1
Lake Tahoe	600	12,535	13,135	4.6
Mojave Desert	957	5,075	6,032	15.9
Mountain Counties	3,767	19,390	23,157	16.3
North Central Coast	2,973	38,235	41,208	7.2
North Coast	1,284	9,525	10,809	11.9
Northeast Plateau	162	2,050	2,212	7.3
Sacramento Valley	24,763	140,315	165,078	15.0
Salton Sea	465	34,325	34,790	1.3
San Diego	3,305	87,444	90,749	3.6
SF Bay Area	2,905	49,644	52,549	5.5
San Joaquin Valley	6,225	58,824	65,049	9.6
South Central Coast	5,878	76,956	82,834	7.1
South Coast	16,158	175,406	191,564	8.4
Totals	70,034	713,524	783,558	**8.9**

5.3.2 Reported Solvent Use Associated With Solvent-Based Coatings

Table 5-5 shows the volumes of various types of solvents that the survey sample reported being used in connection with solvent-based coatings. The responding painters reported using about 21,375 gallons of solvent materials. Figures 5-3 and 5-4 show the distribution of the different solvent materials for thinning and cleaning, respectively.

About one fourth of the solvent volume was used in thinning architectural coatings. Mineral spirits and lacquer thinner accounted for about 85 percent of the volume of thinners. Denatured alcohol comprised 5.4 percent. Small amounts of several other material types were reported.[32]

[32] "Other" includes materials that could not clearly be placed in any other category. "Not Reported" refers to solvents for which names or types were not reported.

Table 5-5

REPORTED VOLUMES OF SOLVENTS ASSOCIATED WITH SOLVENT-BASED ARCHITECTURAL COATINGS

Type of Material	Solvent Use (Gallons/Year)			Percent of Total
	Thinner	Cleanup	Total	
Mineral Spirits	3,392	9,951	13,344	62.4
Lacquer Thinner	1,190	4,222	5,412	25.3
Acetone	134	684	818	3.8
Denatured Alcohol	291	250	541	2.5
Isopropyl Alcohol	5	5	10	0.05
Methanol	0	5	5	0.02
Methylene Chloride	10	5	15	0.1
Naphtha	44	15	59	0.3
Toluene	176	270	446	2.1
Xylene	62	61	122	0.6
Other	73	421	494	2.3
Not Reported	13	97	110	0.5
Totals	5,389	15,986	21,375	100.0

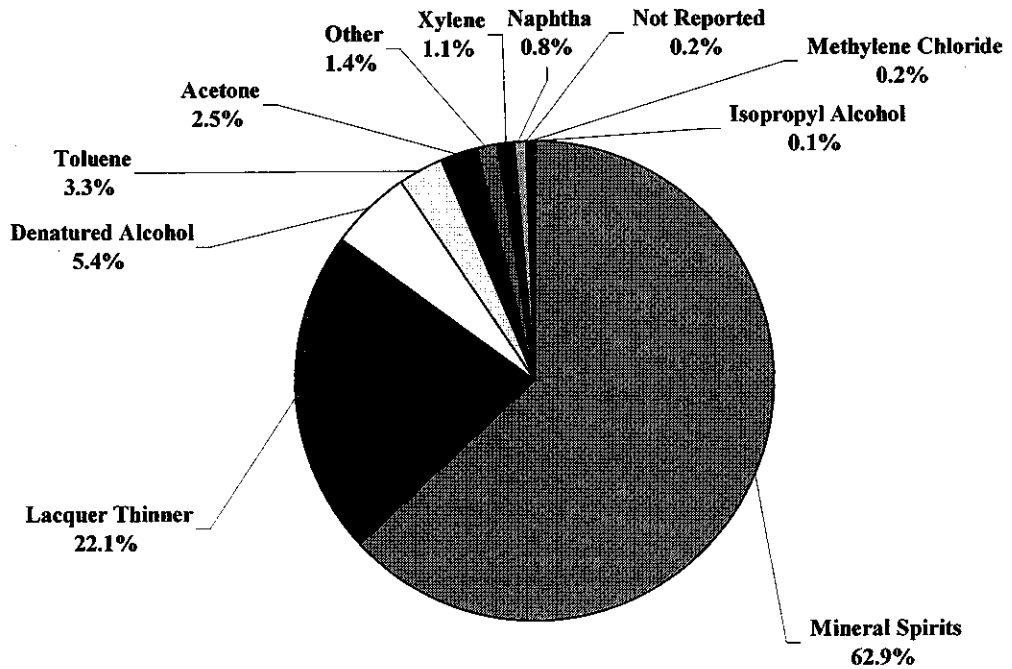

Figure 5-3. Distribution of Reported Thinning Solvent for Solvent-Based Coatings, by Major Product Type.

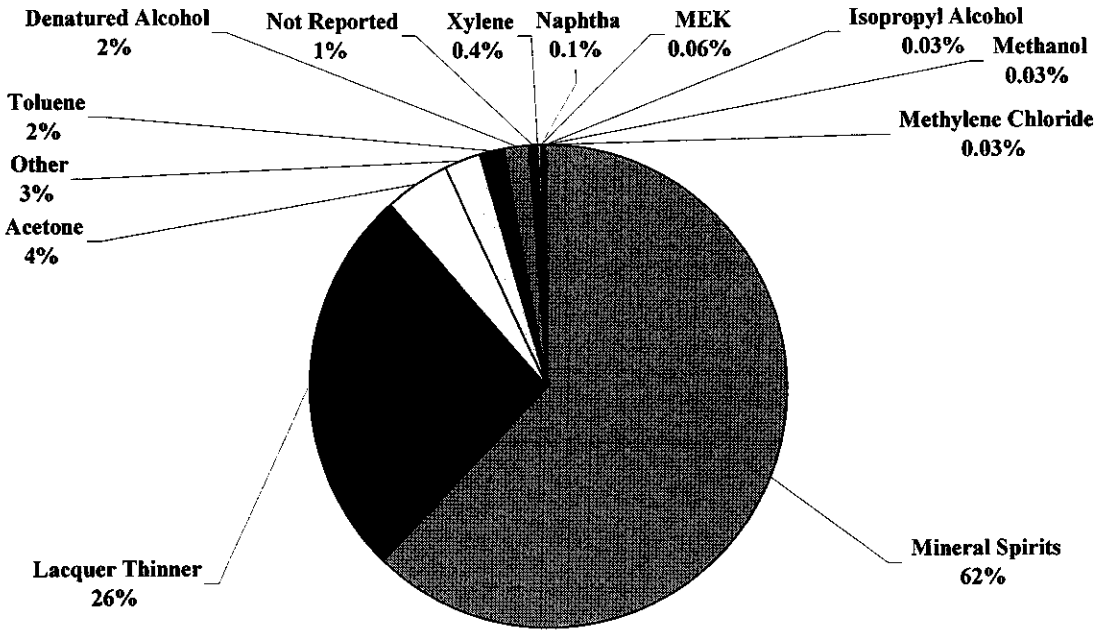

Figure 5-4. Distribution of Reported Cleanup Solvent for Solvent-Based Coatings, by Major Product Type.

For cleaning solvents, mineral spirits and lacquer thinner comprised about 89 percent of the reported volume, while acetone accounted for another 4 percent.

5.3.3 Reported Solvent Use Associated With Water-Based Coatings

For water-borne coatings, the principal "thinner" is water. However, some VOC-containing materials are sometimes added to the coating to improve flow characteristics. In addition, organic solvents are sometimes used to clean brushes, rollers and spray equipment. Table 5-6 shows the volumes of VOC-containing paint additives and cleanup solvents used with water-based coatings, as reported by the survey respondents.

Essentially all the VOC-containing paint additives reported were one of five brands of flow enhancers reported by the painters.[33] The mineral spirits and lacquer thinner reported are anomalous, as those materials are not readily water-soluble.

About 87 percent of the cleanup solvents reported used in conjunction with water-based architectural coatings are mineral spirits. Another 12 percent are various brands of "brush and roller cleaners," whose compositions do not match those of any of the main material categories. Finally, small amounts of lacquer thinner and xylenes were reported.

[33] These are identified in Section 7.3.

Table 5-6

REPORTED VOLUMES OF SOLVENTS ASSOCIATED WITH WATER-BASED ARCHITECTURAL COATINGS

Type of Material	Material Use (Gallons/Year)			Percent of Total
	Additive	Cleanup	Total	
Mineral Spirits	5	2,762	2,767	38.1
Lacquer Thinner	2	1	3	0.0
Flow Enhancer	4,089		4,089	56.4
Xylene		5	5	0.1
Brush and Roller Cleaner		390	390	5.4
Totals	4,096	3,158	7,254	100.0

5.3.4 Ounces of Solvent and Additive per Gallon of Coating

Using the method described in Section 2.5.3.1, we developed estimates of ounces of thinner used per gallon of solvent-based coating. The results for different thinning solvents are shown in Table 5-7. The total solvent use rate is about 9 oz/gal.

We had planned to calculate the oz/gal ratios for cleanup solvents separately for the two coating bases. However, it appeared that some survey respondents had reported their total cleanup solvent without correctly apportioning it between solvent- and water-based coatings. Using the methods described in Section 2.5.3.2, we developed estimates of the weighted average volumes of cleanup solvent used per gallon of solvent- and water-based coating combined. The result was 3.149 oz/gal, with a 90-percent confidence interval of [3.003, 3.295].

Using the method described in Section 2.5.3.3, we calculated a weighted mean of 0.776 ounces of additive per gallon of water-based coating. A 90-percent confidence interval for this value is [0.376, 1.23].

5.3.5 Projected Solvent Volumes for Commercial Painters

5.3.5.1 Thinners Associated With Solvent-Based Coatings

The ARB's 2001 Architectural Coatings Survey (ARB, 2003) estimated statewide use of 16,906,211 gallons of solvent-based architectural and industrial maintenance coatings. As discussed in Section 2.6.1, we estimate that 14,165,520 gallons of solvent-based AIM coatings are used by commercial painters. We multiplied this value by the oz/gal factors in Table 5-7 to obtain statewide thinner estimates by solvent type. The results of this calculation are shown in Table 5-8. We estimate that 979,951 gallons of thinning solvents are used annually by commercial painters. A 90-percent confidence interval for this value is [732,806, 1,250,683] gallons/year.

Table 5-7

OUNCES OF THINNING SOLVENT PER GALLON OF SOLVENT-BASED COATING

Use Category	Mean[a] (oz/gal)	90-Percent Confidence Interval Low (oz/gal)	High (oz/gal)
Mineral Spirits	4.36	3.83	4.92
Lacquer Thinner	2.96	2.24	3.73
Acetone	0.29	0.20	0.39
Denatured Alcohol	0.55	0.10	1.07
Isopropyl Alcohol	0.0093	0.0073	0.012
Methanol			
Methylene Chloride	0.0015	0.00	0.009
Naphtha	0.12	0.052	0.20
Toluene	0.33	0.20	0.47
Xylene	0.079	0.00	0.18
Other	0.136	0.00	0.27
Not Reported	0.020	0.00	0.05
Total	**8.85**	**6.62**	**11.30**

[a]Weighted by gallons of solvent-based coating per facility.

Table 5-8

ESTIMATED STATEWIDE USE OF THINNERS FOR SOLVENT-BASED PAINTS BY COMMERCIAL PAINTERS

Solvent Type	90-Percent Confidence Interval		
	Mean	Low	High
Mineral Spirits	482,804	423,527	544,554
Lacquer Thinner	327,473	247,642	412,814
Acetone	32,274	21,776	43,418
Denatured Alcohol	60,571	10,731	118,371
Isopropyl Alcohol	1,030	805	1,288
Methylene Chloride	161	0	1,002
Naphtha	13,588	5,788	22,191
Toluene	36,042	22,536	51,510
Xylene	8,708	0	19,853
Other	15,035	0	30,049
Not Reported	2,266	0	5,634
Total	**979,951**	**732,806**	**1,250,683**

5.3.5.2 Cleanup Solvents Associated with Architectural Coatings

To obtain an estimate of the volume of cleanup solvents associated with architectural coatings applied by commercial painters, we multiplied the total coating volume (73,394,093 gallons per year) by the cleanup solvent oz/gal ratio presented in Section 5.3.4. The resulting estimate and 90-percent confidence interval are 1,805,609 gallons/year and [1,721,894, 1,889,235] gallons/year. Using our survey's reported distribution of cleanup solvent by solvent type (see Table 5-5), we estimated statewide use by solvent type. These estimates are shown in Table 5-9.

Table 5-9

ESTIMATED STATEWIDE USE OF CLEANUP SOLVENTS BY COMMERCIAL PAINTERS

Type of Material	Solvent Use (Gallons/Year)		
	Mean	Low	High
Mineral Spirits	1,127,178	1,074,918	1,179,438
Lacquer Thinner	457,173	435,977	478,369
Acetone	69,057	65,856	72,259
Denatured Alcohol	45,700	43,582	47,819
Isopropyl Alcohol	845	806	884
Methanol	422	403	442
Methylene Chloride	1,267	1,208	1,326
Naphtha	4,984	4,753	5,215
Toluene	37,675	35,929	39,422
Xylene	10,327	9,848	10,806
Other	41,730	39,795	43,665
Not Reported	9,250	8,821	9,679
Totals	**1,805,609**	**1,721,894**	**1,889,325**

5.3.5.3 Additives Associated With Water-Based Coatings

The estimated use of water-based coatings by commercial painters is 59,228,573 gallons per year. We multiplied the commercial painters' statewide portion of water-based coatings use by the additive/coating ratio of 0.776 ounces per gallon of water-based coating, along with its 90-percent confidence interval limits of [0.376, 1.23] oz/gal, to obtain an estimate of additive use by commercial painters. This value and its 90-percent confidence limits are 359,073 and [173,983, 569,150] gallons per year.

5.3.6 Distribution of Solvent Use by County and Air Basin

Table 5-10 shows the statewide total estimated solvent use, by solvent type. The total for all solvent types combined is 3,127,333 gallons per year, with a 90-percent confidence interval of [2,628,683, 3,673,475]. In Section 2.6.1, we developed estimates of the numbers of commercial painters in each county and air basin in California. To apportion solvent use volumes to these geographic areas, we assumed that solvent use was proportional to the numbers of painters. Tables 5-11 and 5-12 show the apportionment of solvent use by county and air basin, respectively.

Table 5-10

TOTAL ESTIMATED STATEWIDE SOLVENT AND ADDITIVE USE BY COMMERCIAL PAINTERS, BY SOLVENT TYPE
(Gallons per Year)

Type of Material	Thinning			Cleanup			Water-Based Additives			Total		
	Mean	90% Confidence Interval		Mean	90% Confidence Interval		Mean	90% Confidence Interval		Mean	90% Confidence Interval	
		Low	High		Low	High		Low	High		Low	High
Mineral Spirits	482,804	423,527	544,554	1,127,178	1,074,918	1,179,438				1,609,982	1,498,445	1,723,992
Lacquer Thinner	327,473	247,642	412,814	457,173	435,977	478,369				784,645	683,619	891,184
Acetone	32,274	21,776	43,418	69,057	65,856	72,259				101,332	87,632	115,678
Denatured Alcohol	60,571	10,731	118,371	45,700	43,582	47,819				106,271	54,313	166,190
Isopropyl Alcohol	1,030	805	1,288	845	806	884				1,875	1,610	2,172
Methanol				422	403	442				422	403	442
Methylene Chloride	161	0	1,002	1,267	1,208	1,326				1,428	1,208	2,327
Naphtha	13,588	5,788	22,191	4,984	4,753	5,215				18,572	10,541	27,406
Toluene	36,042	22,536	51,510	37,675	35,929	39,422				73,718	58,465	90,933
Xylene	8,708	0	19,853	10,327	9,848	10,806				19,035	9,848	30,658
Other	15,035	0	30,049	41,730	39,795	43,665	359,073	173,983	569,150	415,838	213,778	642,864
Not Reported	2,266	0	5,634	9,250	8,821	9,679				11,515	8,821	15,313
Totals	979,951	732,806	1,250,683	1,805,609	1,721,894	1,889,325	359,073	173,983	569,150	3,144,633	2,628,683	3,709,158

Table 5-11

ESTIMATED ANNUAL USE OF SOLVENTS BY COMMERCIAL PAINTERS, BY COUNTY

(Gallons per Year)

County	Thinner and Cleanup	Water-Base Additive	Total	County	Thinner and Cleanup	Water-Base Additive	Total
Alameda	137,511	17,726	155,237	Orange	281,562	36,295	317,856
Alpine	134	17	152	Placer	27,502	3,545	31,047
Amador	1,881	243	2,124	Plumas	1,433	185	1,618
Butte	12,452	1,605	14,057	Riverside	118,250	15,243	133,494
Calaveras	2,732	352	3,085	Sacramento	88,061	11,351	99,412
Colusa	448	58	506	San Benito	6,898	889	7,787
Contra Costa	109,158	14,071	123,229	San Bernardino	116,100	14,966	131,066
Del Norte	627	81	708	San Diego	273,006	35,192	308,198
El Dorado	15,095	1,946	17,041	San Francisco	89,808	11,577	101,384
Fresno	42,060	5,422	47,481	San Joaquin	34,982	4,509	39,492
Glenn	1,389	179	1,568	San Luis Obispo	20,515	2,644	23,159
Humboldt	8,107	1,045	9,152	San Mateo	67,725	8,730	76,455
Imperial	3,359	433	3,792	Santa Barbara	38,611	4,977	43,588
Inyo	1,523	196	1,719	Santa Clara	144,319	18,604	162,923
Kern	29,966	3,863	33,828	Santa Cruz	17,872	2,304	20,176
Kings	5,241	676	5,916	Shasta	8,421	1,085	9,506
Lake	3,807	491	4,298	Sierra	358	46	405
Lassen	761	98	860	Siskiyou	2,284	294	2,579
Los Angeles	757,923	97,700	855,623	Solano	22,038	2,841	24,878
Madera	5,196	670	5,866	Sonoma	45,464	5,861	51,324
Marin	38,611	4,977	43,588	Stanislaus	32,026	4,128	36,155
Mariposa	985	127	1,112	Sutter	2,284	294	2,579
Mendocino	5,509	710	6,220	Tehama	1,747	225	1,972
Merced	8,555	1,103	9,658	Trinity	717	92	809
Modoc	448	58	506	Tulare	11,064	1,426	12,490
Mono	2,553	329	2,882	Tuolumne	4,390	566	4,955
Monterey	30,055	3,874	33,930	Ventura	54,019	6,963	60,982
Napa	15,722	2,027	17,749	Yolo	17,379	2,240	19,620
Nevada	12,810	1,651	14,462	Yuba	2,105	271	2,377
				State	2,785,560	359,073	3,144,633

Table 5-12

ESTIMATED ANNUAL USE OF SOLVENTS BY COMMERCIAL PAINTERS, BY AIR BASIN

Basin Code	Basin Name	Thinner and Cleanup	Water-Base Additive	Total
GBV	Great Basin Valleys	4,210	543	4,753
LC	Lake County	3,807	491	4,298
LT	Lake Tahoe	4,614	595	5,208
MC	Mountain Counties	38,835	5,006	43,841
MD	Mojave Desert	56,617	7,298	63,915
NC	North Coast	20,559	2,650	23,210
NCC	North Central Coast	54,825	7,067	61,892
NEP	Northeast Plateau	3,494	450	3,944
SC	South Coast	1,197,555	154,371	1,351,926
SCC	South Central Coast	113,144	14,585	127,729
SD	San Diego	273,006	35,192	308,198
SF	San Francisco Bay Area	657,992	84,819	742,811
SJV	San Joaquin Valley	164,028	21,144	185,172
SS	Salton Sea	28,129	3,626	31,755
SV	Sacramento Valley	164,744	21,236	185,981
	Total	2,785,560	359,073	3,144,633

5.4 TEMPORAL PATTERNS

5.4.1 Annual Distribution of Activity

Painters were asked to report the percentage of their annual painting activity that occurred in each month. To calculate mean monthly percentages, we weighted each reported value for a given firm by that firm's total volume of coating use (solvent-borne plus water-borne). 90-percent confidence intervals were determined by bootstrap sampling. Figure 5-5 shows the results of the calculations. The horizontal line indicates uniform monthly activity (8.33 percent per month). Commercial painting activity in California is clearly seasonal. As one would expect, it is relatively high from April through October, and relatively low from November through March. Figure 5-6 shows the mean percentage of annual activity by season.

Table 5-13 shows the mean monthly percents by air basin. For most of the basins, the monthly distribution of activity is similar to that for the State as a whole. However, in the Mountain Counties, North Coast and San Francisco Bay Area air basins, there appears to be a higher concentration of activity in the summer than for the State.

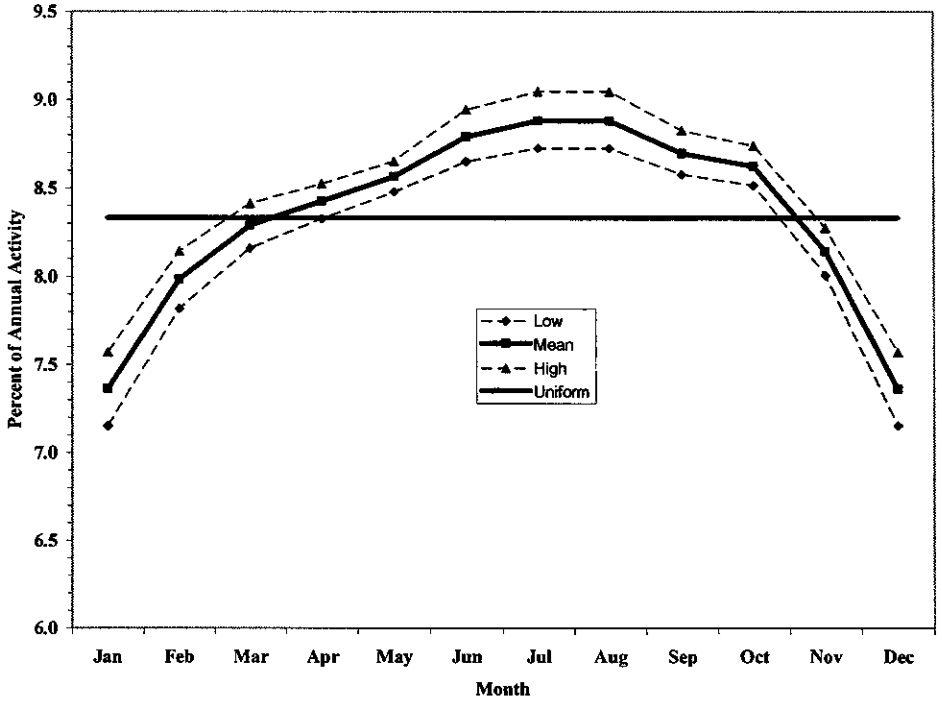

Figure 5-5. Mean and 90-Percent Confidence Interval for Monthly Percentages of Commercial Painting Activity.

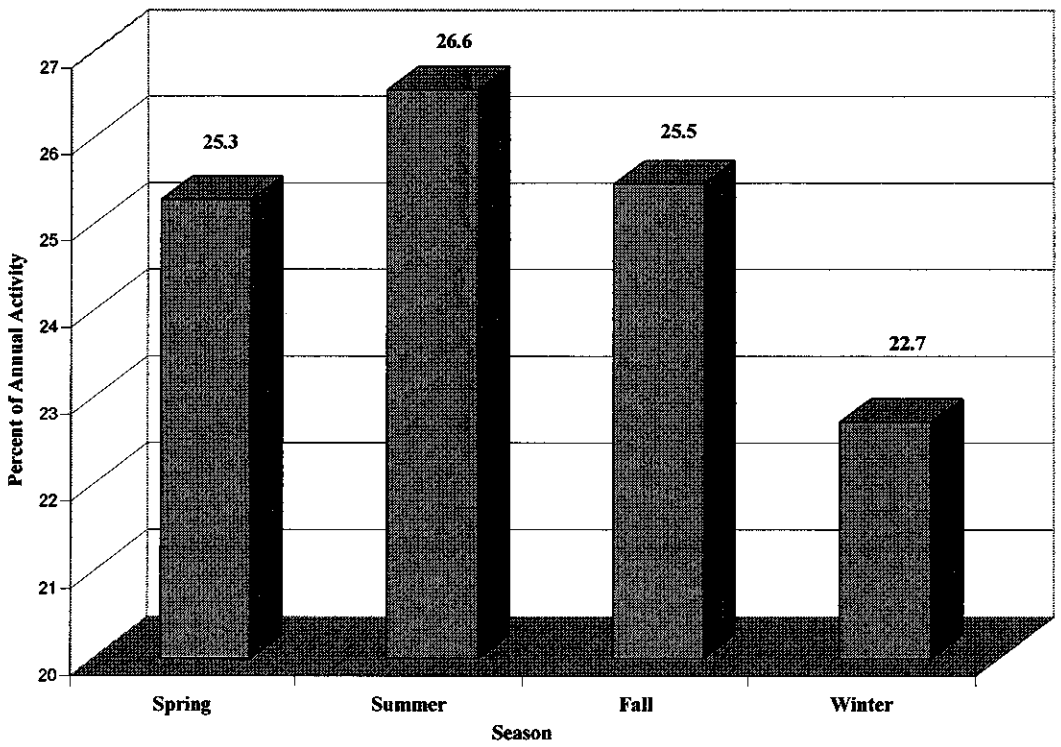

Figure 5-6. Mean Percentage of Annual Commercial Painting Activity, by Season.

Table 5-13

PERCENTAGE OF ANNUAL ACTIVITY PER MONTH, BY AIR BASIN, FOR COMMERCIAL PAINTERS

Air Basin	n	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Great Basin Valleys	4	1.44	0.83	3.60	3.60	3.60	3.60	19.95	19.95	19.95	19.95	2.06	1.44
Lake County	2	4.51	9.61	9.61	9.61	9.61	9.61	9.61	9.61	9.61	9.61	4.51	4.51
Lake Tahoe	2	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
Mojave Desert	4	8.14	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.14	8.14
Mountain Counties	7	5.03	6.53	6.75	6.75	10.07	10.07	10.07	10.07	10.07	10.07	7.58	6.93
North Central Coast	16	7.88	7.91	8.46	8.52	8.52	8.52	8.52	8.52	8.52	8.35	8.45	7.84
North Coast	6	5.50	5.50	8.97	8.97	9.31	11.07	11.07	11.07	10.18	10.18	6.48	1.70
Northeast Plateau	1	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
Sacramento Valley	26	7.68	7.80	7.83	8.46	8.49	8.80	8.80	8.80	8.80	8.46	8.22	7.87
Salton Sea	6	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
San Diego	27	6.08	8.27	8.88	8.88	8.88	8.88	8.88	8.88	8.88	8.88	8.88	5.76
SF Bay Area	22	7.22	7.73	7.46	7.66	8.06	10.06	10.06	10.06	8.06	8.06	8.02	7.55
San Joaquin Valley	30	7.50	7.76	8.51	8.51	8.68	8.68	8.68	8.68	8.51	8.51	8.48	7.50
South Central Coast	26	6.96	8.79	8.85	8.85	8.85	8.83	8.83	8.83	8.76	8.76	6.87	6.83
South Coast	37	7.90	8.02	8.35	8.35	8.47	8.58	8.58	8.58	8.47	8.47	8.33	7.90
State	216	7.36	7.98	8.29	8.43	8.56	8.79	8.88	8.88	8.70	8.62	8.14	7.36

5.4.2 Weekday Vs Weekend

Painters were asked to report whether they painted during the week, on Saturday, and/or on Sunday. The purpose of the question was to obtain data for estimating the percentage of weekly activity that occurs during each of the three time periods. Table 5-14 shows the results, by season, for the State. The activity for each reporting facility was weighted by the facility's total coating use. It is clear that about 94 percent of the commercial painting activity is during the week, regardless of the season of year. Saturday and Sunday account for about 5 and 1 percent of the activity, respectively.

Table 5-14

WEEKDAY VS WEEKEND DISTRIBUTION OF PAINTING ACTIVITY

Season	Weekday	Saturday	Sunday
Spring	94.07	4.85	1.08
Summer	93.87	4.98	1.15
Fall	94.26	4.69	1.06
Winter	94.50	4.35	1.15

5.4.3 Diurnal Patterns

We also asked painters to report the hours of day when they apply paint and/or use cleanup solvents.[34] Figure 5-7 through 5-10 show the results statewide for each season. Each facility's response was weighted by the sum of its solvent- and water-based coating use. The bars represent the percent of each day's activity that occurs during each hour. The patterns for the four seasons are very similar. All show a dip during the hour from noon to 1 p.m., presumably for a lunch break. The hour of maximum activity, in all seasons, is 3 to 4 p.m. Painters work slightly later in summer than in the other seasons.

[34] We also asked them to identify the hours when cleanup solvents were used, but very few did.

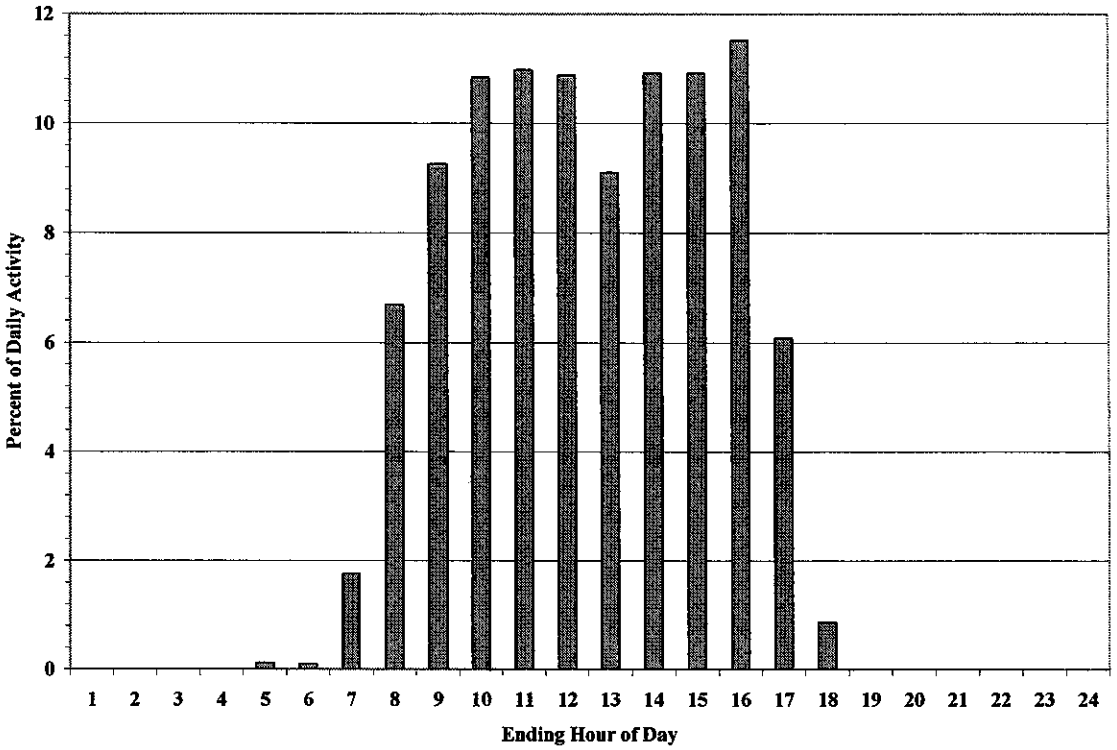

Figure 5-7. Diurnal Pattern of Commercial Painting Activity: Spring.

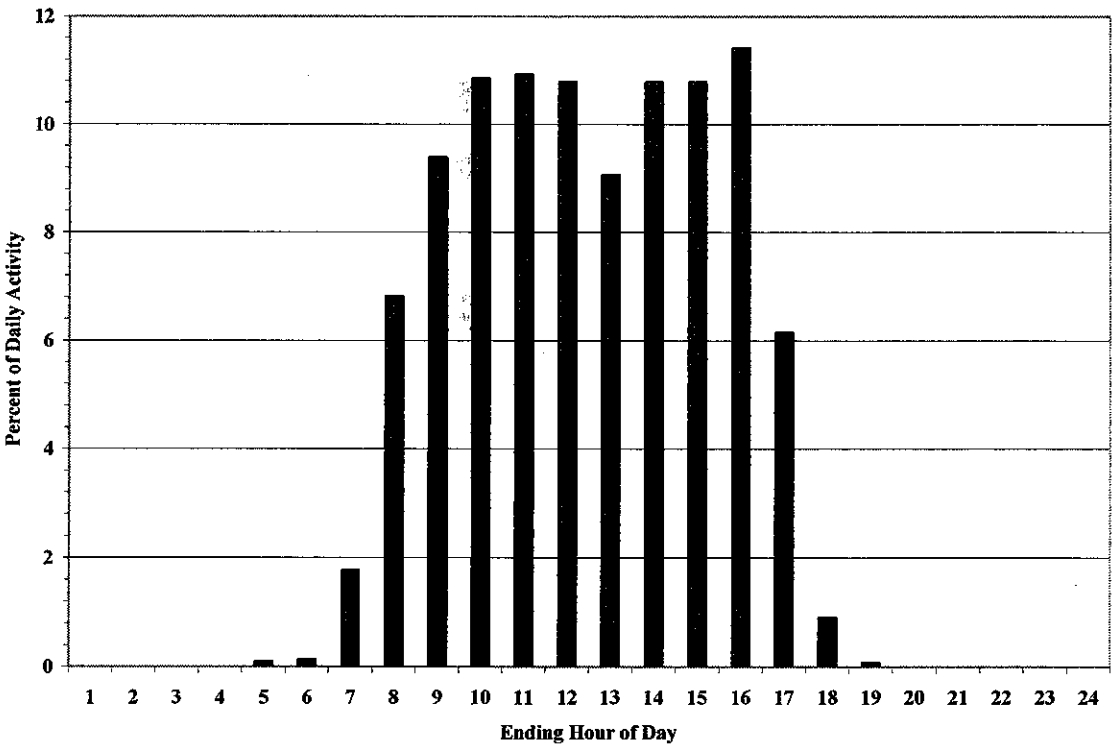

Figure 5-8. Diurnal Pattern of Commercial Painting Activity: Summer.

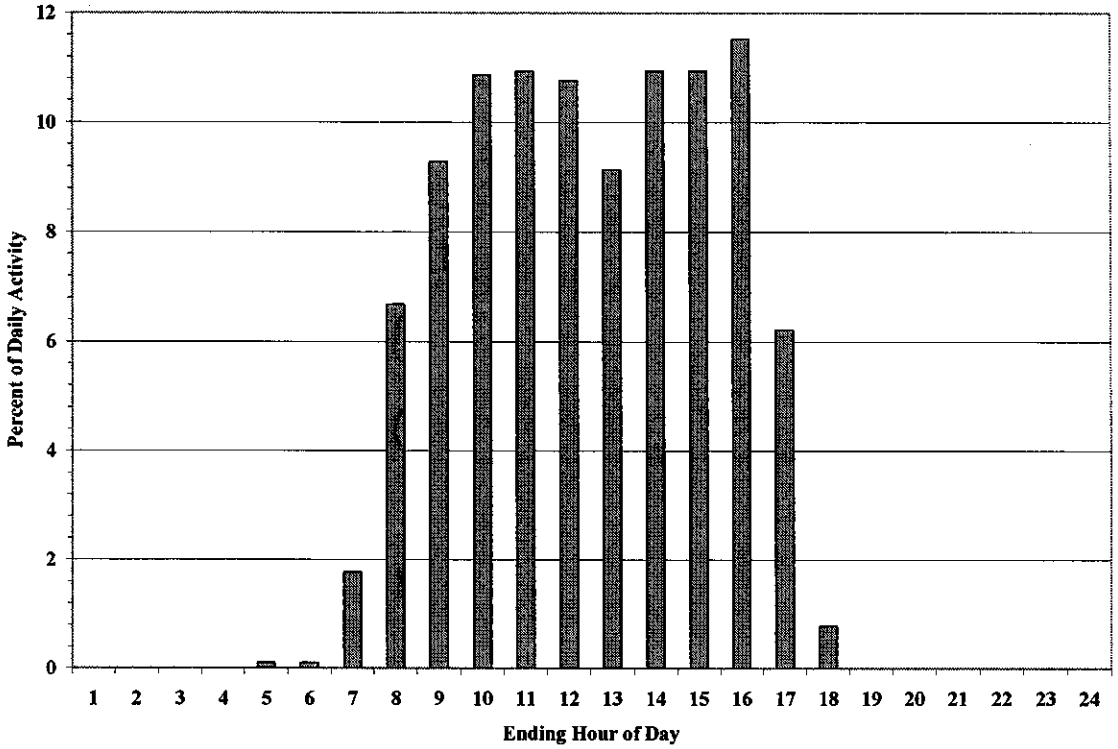

Figure 5-9. Diurnal Pattern of Commercial Painting Activity: Fall.

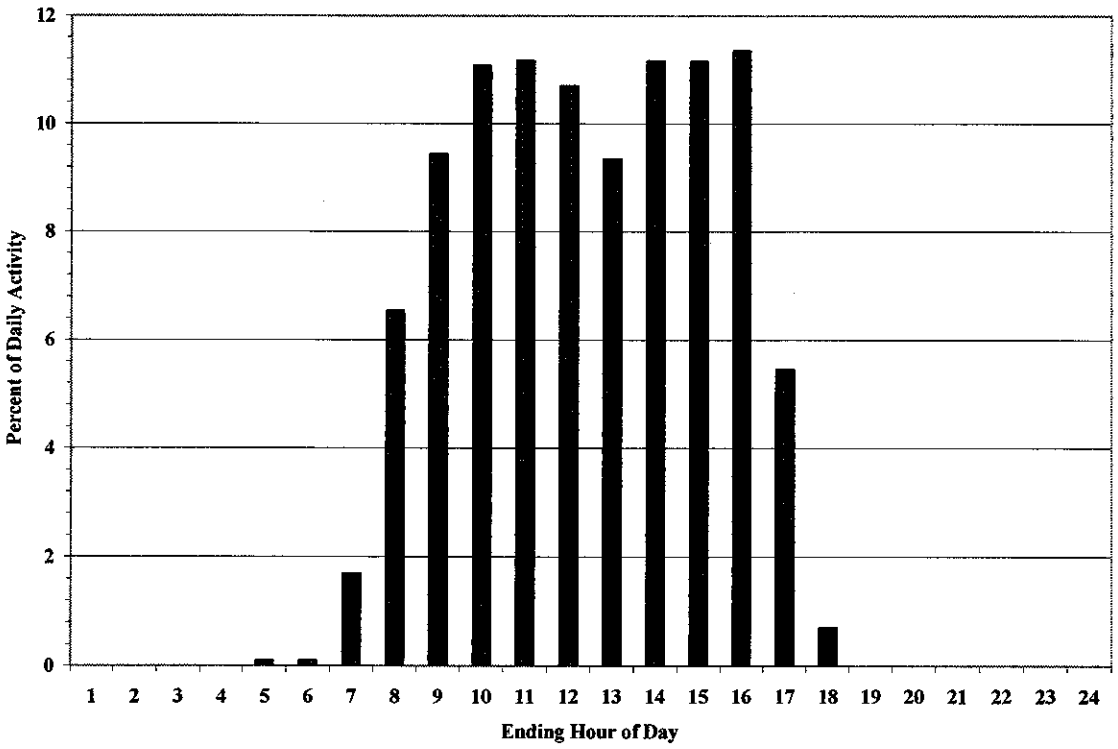

Figure 5-10. Diurnal Pattern of Commercial Painting Activity: Winter.

5.5 WEATHER EFFECTS

Painters were asked how unusually hot or cold weather, or rain or snow would affect their painting activity. For each condition, they were given the following choices, not all of which needed be mutually exclusive:

- Not paint on those days
- Use less or more thinner per gallon of paint than "normal"
- Use different thinners than on "normal" days
- Use different cleanup solvents than on "normal" days
- Paint earlier in the day
- Paint later in the day
- Paint as normal

"Hot" days were defined as those above 90°F, while "cold" days were defined as those below 40°F.

Table 5-15 shows the responses, by basin, for the case of unusually hot weather. Responses were weighted by total reported gallons of paint used (solvent- and water-based). It appears that hot weather would not significantly influence painting activity. For 7 of the 15 air basins, more than 80 percent of the painting activity would be at "normal" levels. The major exceptions were the Great Basin Valleys, Mountain Counties, and South Central Coast air basins, in which 21 to 65 percent of the responding painters would not paint in hot weather. The most common responses to hot weather (other than not painting at all), statewide, were painting earlier or later in the day. The only place where painters said that they would use a different cleanup solvent in hot weather was the San Diego Air Basin; 14 percent would do so.

Table 5-16 shows the responses for the case of unusually cold weather. Cold weather appears to have a somewhat greater effect on painting activity than does hot weather. Statewide, about a third of the activity would not take place on cold days. In 11 of the 15 air basins, at least one quarter of the activity would cease. The most common responses to very cold weather (other than not painting at all), statewide, were painting later in the day or using a different thinner. The only place where painters said that they would use a different cleanup solvent in cold weather was the San Diego Air Basin; 3 percent would do so.

Table 5-17 shows the responses for the case of rain or snow. Almost 60 percent of the painting activity, statewide, would stop in inclement weather. In three air basins (Lake County, San Diego, and South Coast), more than half the painting activity would continue as normal. Very few painters reported that they would alter their painting activity other than to not paint; they would use less thinner, use a different thinner, or paint earlier or later in the day.

Table 5-15

EFFECT OF UNUSUALLY HOT WEATHER ON COMMERCIAL PAINTING ACTIVITY

Air Basin	n	Percent of Responses							
		Not Paint	Use Less Thinner	Use More Thinner	Use Different Thinner	Use Different Cleanup Solvent	Paint Earlier in Day	Paint Later in Day	Paint as Normal
Great Basin Valleys	4	65.4	0.0	0.0	0.0	0.0	22.3	9.9	12.3
Lake County	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Lake Tahoe	2	0.0	0.0	0.0	0.0	0.0	96.3	96.3	3.7
Mojave Desert	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Mountain Counties	7	41.5	0.0	0.0	11.8	0.0	26.2	4.6	32.3
North Central Coast	15	0.8	0.0	0.0	0.0	0.0	4.8	3.8	93.8
North Coast	6	9.4	0.0	0.0	0.0	0.0	2.7	0.0	90.6
Northeast Plateau	2	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Sacramento Valley	27	0.3	0.0	0.0	1.7	0.0	5.7	3.1	93.9
Salton Sea	6	0.0	0.0	0.0	0.0	0.0	54.2	52.7	45.8
San Diego	28	3.4	2.8	13.1	4.0	14.0	8.4	3.0	75.5
SF Bay Area	23	2.3	6.3	3.0	0.0	0.0	3.0	2.6	84.8
San Joaquin Valley	30	2.2	7.5	0.5	0.0	0.0	37.9	4.7	57.0
South Central Coast	26	21.1	1.4	2.4	0.0	0.0	55.8	19.4	24.5
South Coast	40	1.0	2.6	1.0	1.8	0.0	13.2	5.3	83.2
State	223	4.6	2.2	2.3	1.5	1.7	20.4	9.4	72.2

Table 5-16

EFFECT OF UNUSUALLY COLD WEATHER ON COMMERCIAL PAINTING ACTIVITY

Air Basin	n	Percent of Responses							
		Not Paint	Use Less Thinner	Use More Thinner	Use Different Thinner	Use Different Cleanup Solvent	Paint Earlier in Day	Paint Later in Day	Paint as Normal
Great Basin Valleys	4	87.7	0.0	0.0	0.0	0.0	0.0	12.3	0.0
Lake County	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Lake Tahoe	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Mojave Desert	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Mountain Counties	6	55.4	0.0	0.0	38.5	0.0	0.0	18.5	7.3
North Central Coast	15	27.4	0.0	0.0	0.0	0.0	0.0	1.3	72.6
North Coast	5	26.3	0.0	0.0	0.0	0.0	0.0	0.0	73.7
Northeast Plateau	2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sacramento Valley	27	24.6	0.0	0.0	0.2	0.0	0.0	3.2	72.2
Salton Sea	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
San Diego	28	45.0	1.3	0.0	4.0	2.8	0.6	2.8	47.9
SF Bay Area	22	33.3	6.6	0.0	0.0	0.0	0.0	0.5	60.0
San Joaquin Valley	30	32.5	0.0	0.5	0.0	0.0	0.4	14.6	55.1
South Central Coast	26	58.5	1.4	0.0	0.0	0.0	0.0	2.2	41.6
South Coast	38	27.9	0.0	0.0	0.0	0.0	1.3	2.4	69.7
State	217	32.3	0.7	0.0	1.2	0.3	0.4	3.7	63.4

Table 5-17

EFFECT OF RAIN OR SNOW ON COMMERCIAL PAINTING ACTIVITY

Air Basin	n	Percent of Responses							
		Not Paint	Use Less Thinner	Use More Thinner	Use Different Thinner	Use Different Cleanup Solvent	Paint Earlier in Day	Paint Later in Day	Paint as Normal
Great Basin Valleys	4	77.7	0.0	0.0	0.0	0.0	0.0	12.3	9.9
Lake County	2	45.9	0.0	0.0	0.0	0.0	0.0	0.0	54.1
Lake Tahoe	2	96.3	0.0	0.0	0.0	0.0	0.0	0.0	3.7
Mojave Desert	5	85.5	0.0	0.0	0.0	0.0	0.0	0.0	14.5
Mountain Counties	7	70.2	0.0	0.0	37.1	0.0	0.0	0.0	4.6
North Central Coast	14	97.9	0.0	0.0	0.0	0.0	0.0	0.0	2.1
North Coast	5	90.6	0.0	0.0	0.0	0.0	0.0	0.0	9.4
Northeast Plateau	2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sacramento Valley	27	52.7	0.0	0.0	0.0	0.0	0.0	0.0	47.3
Salton Sea	6	98.4	0.0	0.0	0.0	0.0	0.0	0.0	1.6
San Diego	28	47.9	0.0	0.0	0.0	0.0	0.0	0.0	52.1
SF Bay Area	23	43.2	28.6	0.0	0.0	0.0	0.0	0.4	28.7
San Joaquin Valley	30	92.6	0.0	0.0	0.0	0.0	0.5	0.5	8.0
South Central Coast	26	96.4	0.0	0.0	0.0	0.0	0.0	0.0	3.6
South Coast	40	28.6	0.0	0.0	0.0	0.0	0.0	0.0	71.4
State	221	60.0	1.7	0.0	0.6	0.0	0.0	0.1	37.9

6.0

RESULTS OF THE HOMEOWNERS SURVEY

In reading the following sections, it is helpful to understand how the telephone survey of homeowners was conducted. First, we eliminated people who were not homeowners and/or who had not painted in the past five years. We then asked the homeowners about their temporal patterns and their responses to extremes of weather. Therefore the responses for those areas of inquiry pertain to use of both solvent- and water-based coatings. We then asked each homeowner whether he or she had used solvent-based paintings. Those who had not were asked no more questions. Thus the responses regarding use of solvents pertain to a subset of all respondents.

6.1 SURVEY RESPONSE

Table 6-1 characterizes the response to the homeowners survey. We were able to contact and interview 2,196 households, or 56 percent of the potential sample. Of these, 238 did not meet the criteria for this survey, i.e. they were businesses or were not owner-occupied households. That left 1,958 eligible households. We obtained at least some useful information[35] from 1,059 households, or 54 percent of those that were eligible. Detailed responses to most or all of the survey questions were obtained from 609 households, or 31 percent of those that were eligible.

6.2 CHARACTERISTICS OF THE SURVEY SAMPLE

6.2.1 Geographic Distribution

Tables 6-2 and 6-3 show the geographic distributions, by county and air basin, respectively, of households that provided "useful" information, as defined above. Responding households are in 45 counties and 14 air basins. (No responses were received from the Lake Tahoe Air Basin.) As seen in Table 6-3, the sample's distribution by air basin closely matches the distribution of owner-occupied households for the same geographic area.

6.2.2 Housing Type

Of the 609 household respondents that provided detailed data on painting activity, 594 (97.5 percent) stated that they had a single-family, detached home. Other housing types reported were three duplexes, four townhouses, and four apartments or condominiums. Housing type data were missing for four households.

Unfortunately, we did not record the homeowners' responses as to housing type for households that reported that they had done no painting. The only information on housing type for these residences is a code assigned by the database provider; it indicates

[35] "Useful information" includes activity data reported, plus a response that the household did no painting in the past five years; the latter was used to estimate the proportion of California households that do their own painting.

Table 6-1

RESPONSES TO THE HOMEOWNERS SURVEY

TOTAL POTENTIAL SAMPLE			3,889
Unable to Respond			1,693
	Telephone Disconnected	280	
	Not English Speaking	2	
	Fax or Modem	26	
	Deceased	2	
	Hearing Impaired	1	
	Qualified Person Not Home or No Answer	1,310	
	Not Called	72	
AVAILABLE FOR SURVEY			2,196
Ineligible for the Survey			238
	Residence But Not Owner-Occupied	219	
	Business	19	
ELIGIBLE AND AVAILABLE FOR THE SURVEY			1,958
Refused to Respond			896
Provided Useful Information			1,059
	No Painting in Past Five Years	427	
	Painted and Provided Detailed Data	609	
	Used Solvent-Based Paints: 235 Did Not Use Solvent-Based Paints: 374		
	Painted But Provided No Details	23	

Table 6-2

DISTRIBUTION OF SURVEY SAMPLE BY COUNTY
(Households Providing Full or Partial Data or Reporting No Painting)

County	No. of Responses	Percent of Responses	County	No. of Responses	Percent of Responses
Alameda	44	4.2	Sacramento	54	5.1
Butte	9	0.8	San Bernardino	51	4.8
Contra Costa	48	4.5	San Diego	84	7.9
El Dorado	8	0.8	San Francisco	15	1.4
Fresno	32	3.0	San Joaquin	14	1.3
Humboldt	4	0.4	San Luis Obispo	8	0.8
Imperial	1	0.1	San Mateo	25	2.4
Inyo	1	0.1	Santa Barbara	15	1.4
Kern	28	2.6	Santa Clara	69	6.5
Kings	5	0.5	Santa Cruz	9	0.8
Lake	4	0.4	Shasta	6	0.6
Lassen	1	0.1	Siskiyou	4	0.4
Los Angeles	221	20.9	Solano	20	1.9
Madera	2	0.2	Sonoma	15	1.4
Marin	15	1.4	Stanislaus	13	1.2
Mendocino	4	0.4	Sutter	2	0.2
Merced	5	0.5	Tehama	2	0.2
Monterey	10	0.9	Tulare	6	0.6
Napa	6	0.6	Tuolumne	4	0.4
Nevada	9	0.8	Ventura	30	2.8
Orange	89	8.4	Yolo	7	0.7
Placer	10	0.9	Yuba	2	0.2
Riverside	48	4.5	Totals	1,059	100.0

Table 6-3

DISTRIBUTION OF SURVEY SAMPLE BY AIR BASIN
(Households Providing Full or Partial Data or Reporting No Painting)

Air Basin	No. of Responses	Percent of Responses	Basin's Percent of California Households[a]
Great Basin Valleys	1	0.1	0.1
Lake County	4	0.4	0.3
Lake Tahoe	0	0.0	0.2
Mojave Desert	36	3.4	2.3
Mountain Counties	21	2.0	1.8
North Central Coast	19	1.8	2.0
North Coast	12	1.1	1.1
Northeast Plateau	5	0.5	0.3
Sacramento Valley	112	10.6	8.0
Salton Sea	16	1.5	1.5
San Diego	84	7.9	8.4
San Francisco Bay	233	22.0	21.1
San Joaquin Valley	99	9.3	9.1
South Central Coast	53	5.0	4.6
South Coast	364	34.4	39.1
Totals	1,059	100.0	100.0

[a]See Table 6-13.

whether the housing is single- or multi-family. As a check on the accuracy of this characterization, we looked at the subset of residences that furnished complete solvent use data. As noted above, 97.5 percent of these were self-reported as single-family homes. For this subset of residences, the database provider had 91 percent coded as single-family and 9 percent as multifamily. Although one would wish the two percentages to be closer, it does appear that the database provider's characterization is reasonably accurate. This being said, we determined that of the households that reported no painting or that had done painting but provided no data, 76.9 percent were single-family homes.

6.2.3 Fraction Who Painted in the Past Five Years

The fraction of survey respondents in a given basin who reported having painted (with either solvent- or water-based paints) during the previous five years ranged from 0.43 to 1. The statewide average was 0.60. Table 6-4 shows the reported painting fractions and their 90-percent confidence intervals, by air basin. The confidence intervals for the air basins are shown, in descending order of reported painting fraction, in Figure 6-1. From the figure, it can be seen that the fraction who paint does not vary significantly among

Table 6-4

FRACTION OF OWNER-OCCUPIED HOUSEHOLDS WHO PAINTED DURING THE PAST FIVE YEARS, BY AIR BASIN

Air Basin	n	Fraction Who Paint	90-Percent Confidence Interval	
			Lower	Upper
Great Basin Valleys	1	1	1	1
Lake County	4	1	1	1
Mojave Desert	36	0.556	0.444	0.667
Mountain Counties	21	0.429	0.286	0.571
North Central Coast	19	0.632	0.474	0.789
North Coast	12	0.667	0.500	0.833
Northeast Plateau	5	0.600	0.400	0.800
Sacramento Valley	112	0.652	0.589	0.714
Salton Sea	16	0.563	0.375	0.688
San Diego	84	0.583	0.512	0.655
San Francisco Bay	233	0.627	0.584	0.665
San Joaquin Valley	99	0.475	0.414	0.535
South Central Coast	53	0.585	0.491	0.679
South Coast	364	0.604	0.571	0.637
Statewide	1,059	0.597	0.578	0.617

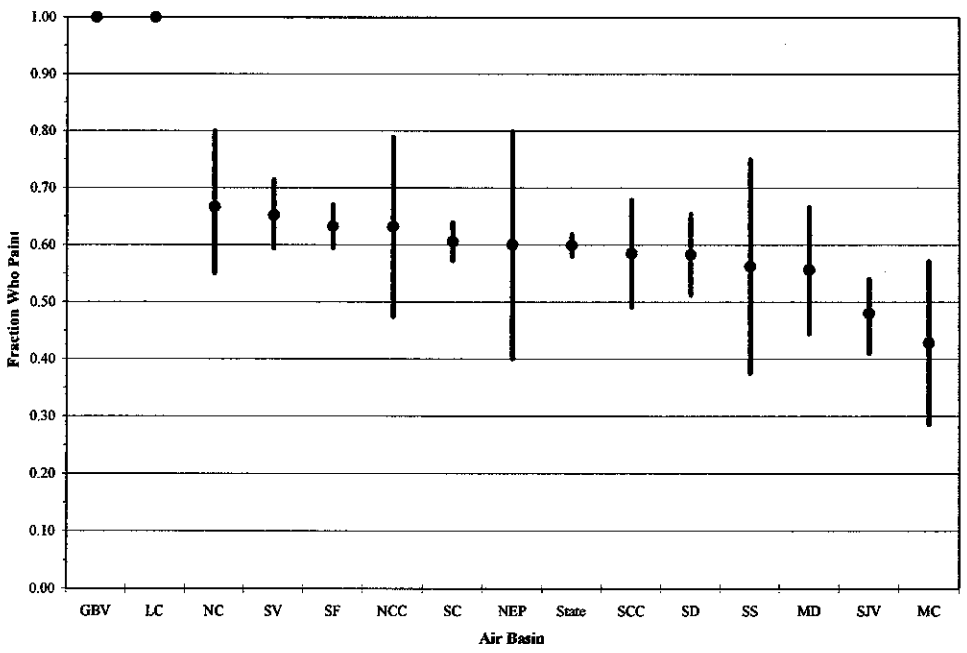

Figure 6-1. Fraction of Owner-Occupied Households Who Painted During the Past Five Years, by Air Basin.

most of the air basins. However, the fraction seems to be significantly higher ($p < 0.10$) for the Sacramento Valley, San Francisco Bay and South Coast Air Basins than it is for the San Joaquin Valley Air Basin.

6.3 SOLVENT USE RESULTS

The results in this section pertain to the homeowners who answered "Yes" to the survey question, "Did you use oil-based paints for any of the painting that you did?"

6.3.1 Solvent Materials Associated With Use of Solvent-Based Coatings

Homeowners reported use of seven major types of solvents:

- Mineral spirits
- Lacquer thinner
- Acetone
- Turpentine
- Naphtha
- Toluene
- Other (unidentified)

Households reported the pints and quarts of thinning and cleanup solvents that they had purchased during the last five years. These volumes were converted to gallons and segregated by solvent type (mineral spirits, lacquer thinner, etc.). Table 6-5 shows the reported five-year volumes of thinning and cleanup solvents by air basin. We then calculated the mean and, by bootstrap sampling, the 90-percent confidence intervals of five-year solvent use per household for each basin. The results of these calculations are shown in Tables 6-6 and 6-7. The last rows of Tables 6-6 and 6-7 show the results when all the survey data are pooled. For most air basins, the mean solvent consumption per household does not differ significantly from the statewide mean. However, the following basin means are significantly different from the statewide value:

- North Central Coast: lacquer thinner (lower)
- San Francisco Bay: mineral spirits (lower) and lacquer thinner (lower)
- Lake County: turpentine (higher)

The values shown in Tables 6-6 and 6-7 will be used later in this chapter to develop estimates of solvent consumption.

6.3.2 Mode of Use (Thinning vs. Cleanup)

Homeowners were asked to state the percentage, within specified ranges, of their total solvent use that was devoted to paint thinning (as opposed to cleanup). Table 6-8 shows the reported five-year volumes of solvent in each percentage range. Figure 6-2 shows the distributions of the thinner percent ranges for mineral spirits, lacquer thinner, and acetone. Figure 6-3 shows them for turpentine, naphtha, toluene, and "other" solvents. In all

Table 6-5

THINNING AND CLEANUP SOLVENT PURCHASED BY RESPONDING HOUSEHOLDS IN PREVIOUS FIVE YEARS (Gallons)

Air Basin	n	Mineral Spirits	Lacquer Thinner	Acetone	Turpentine	Naphtha	Toluene	Other	Total for Basin
Great Basin Valleys	1				0.375				0.375
Lake County	4		0.250		0.625				0.88
Mojave Desert	36	1.000	0.500		0.000			1.375	2.88
Mountain Counties	21	1.000	0.500	0.125					1.63
North Central Coast	19	1.000	0.250		0.250				1.50
North Coast	12		0.250	1.250	5.250			0.250	7.00
Northeast Plateau	5	No Solvent Use Reported							
Sacramento Valley	112	4.875	6.500	0.500	2.125	0.250		1.000	15.25
Salton Sea	16		0.125	0.375				0.125	0.63
San Diego	84	1.125	5.125	1.375	0.000	1.250		1.375	10.25
San Francisco Bay	233	3.000	3.500	1.750	1.625	1.625	0.375	0.750	12.63
San Joaquin Valley	99	3.250	4.375	0.500	0.500			0.375	9.00
South Central Coast	53	1.875	3.125	0.375				0.125	5.50
South Coast	364	9.875	11.500	5.750	5.375	0.625	0.375	0.750	34.25
Statewide	1,059	27.00	36.00	12.00	16.13	3.75	0.75	6.13	101.75

Table 6-6

FIVE-YEAR CONSUMPTION OF MINERAL SPIRITS, LACQUER THINNER AND ACETONE PER HOUSEHOLD THAT USES SOLVENT-BASED COATINGS, BY AIR BASIN

(Units in Gallons per Five Years per Household)

Air Basin	n	Mineral Spirits			Lacquer Thinner			Acetone		
		90-Percent Confidence Interval			90-Percent Confidence Interval			90-Percent Confidence Interval		
		Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Great Basin Valleys	1									
Lake County	4				0.0625	0.0000	0.1250			
Mojave Desert	36	0.0278	0.0000	0.0556	0.0139	0.0000	0.0278			
Mountain Counties	21	0.0476	0.0000	0.0952	0.0238	0.0000	0.0476	0.0060	0.0000	0.0119
North Central Coast	19	0.0526	0.0000	0.1053	0.0132	0.0000	0.0263			
North Coast	12				0.0208	0.0000	0.0455	0.1042	0.0000	0.2083
Northeast Plateau	5									
Sacramento Valley	112	0.0435	0.0167	0.0737	0.0580	0.0257	0.0949	0.0045	0.0000	0.0089
Salton Sea	16				0.0078	0.0000	0.0156	0.0234	0.0000	0.0469
San Diego	84	0.0134	0.0060	0.0223	0.0610	0.0223	0.1057	0.0164	0.0074	0.0268
San Francisco Bay	233	0.0129	0.0086	0.0177	0.0150	0.0064	0.0247	0.0075	0.0043	0.0107
San Joaquin Valley	99	0.0328	0.0152	0.0530	0.0442	0.0177	0.0732	0.0051	0.0000	0.0101
South Central Coast	53	0.0354	0.0071	0.0660	0.0590	0.0189	0.1061	0.0071	0.0000	0.0142
South Coast	364	0.0271	0.0189	0.0361	0.0316	0.0206	0.0433	0.0158	0.0093	0.0227
Statewide	1,059	0.0255	0.0202	0.0311	0.0340	0.0267	0.0416	0.0113	0.0083	0.0144

Table 6-7

FIVE-YEAR CONSUMPTION OF TURPENTINE, NAPHTHA, TOLUENE AND OTHER SOLVENT PER HOUSEHOLD THAT USES SOLVENT-BASED COATINGS, BY AIR BASIN

(Units in Gallons per Five Years per Household)

Air Basin	n	Turpentine			Naphtha			Toluene			Other		
		90-Percent Confidence Interval			90-Percent Confidence Interval			90-Percent Confidence Interval			90-Percent Confidence Interval		
		Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Great Basin Valleys	1	0.3750	0.3750	0.3750									
Lake County	4	0.1563	0.0313	0.2813									
Mojave Desert	36										0.0382	0.0000	0.0764
Mountain Counties	21												
North Central Coast	19	0.0132	0.0000	0.0263									
North Coast	12	0.4375	0.0000	0.8750							0.0208	0.0000	0.0417
Northeast Plateau	5												
Sacramento Valley	112	0.0190	0.0022	0.0368	0.0022	0.0000	0.0045				0.0089	0.0000	0.0179
Salton Sea	16										0.0078	0.0000	0.0156
San Diego	84				0.0149	0.0000	0.0298				0.0164	0.0030	0.0327
San Francisco Bay	233	0.0070	0.0021	0.0123	0.0070	0.0000	0.0139	0.0016	0.0000	0.0032	0.0032	0.0011	0.0054
San Joaquin Valley	99	0.0051	0.0000	0.0101							0.0038	0.0000	0.0076
South Central Coast	53										0.0024	0.0000	0.0047
South Coast	364	0.0148	0.0055	0.0254	0.0017	0.0000	0.0034	0.0010	0.0000	0.0021	0.0021	0.0007	0.0034
Statewide	1,059	0.0152	0.0090	0.0222	0.0039	0.0017	0.0063	0.0007	0.0002	0.0012	0.0058	0.0034	0.0084

Table 6-8

REPORTED FIVE-YEAR SOLVENT VOLUMES, BY SOLVENT TYPE AND PERCENTAGE USED AS THINNER (Gallons)

Solvent Type	Mean Use Per Household (Gal/5 Yrs)	Distribution of Total Reported Five-Year Solvent Use by Percent Used as Thinner								
		None	1 - 10%	10 - 25%	25 - 50%	50 - 75%	75 - 90%	100%	Thinner Percent Not Reported	Total
Mineral Spirits	0.0255	4.500	9.250	2.875	5.875	3.250	0.000	0.000	1.250	27.00
Lacquer Thinner	0.0340	10.000	8.125	9.875	3.625	3.750	0.000	0.000	0.625	36.00
Acetone	0.0113	0.000	2.625	4.625	2.625	1.500	0.125	0.000	0.500	12.00
Turpentine	0.0152	4.250	1.625	1.500	5.000	2.750	1.000	0.000	0.000	16.13
Naphtha	0.0039	0.000	0.250	0.375	0.000	1.875	1.250	0.000	0.000	3.75
Toluene	0.0007	0.000	0.500	0.250	0.000	0.000	0.000	0.000	0.000	0.75
Other	0.0058	0.375	2.500	1.250	0.000	0.000	0.250	0.000	1.750	6.13
Totals		19.13	24.88	20.75	17.13	13.13	2.63	0.00	4.13	101.75

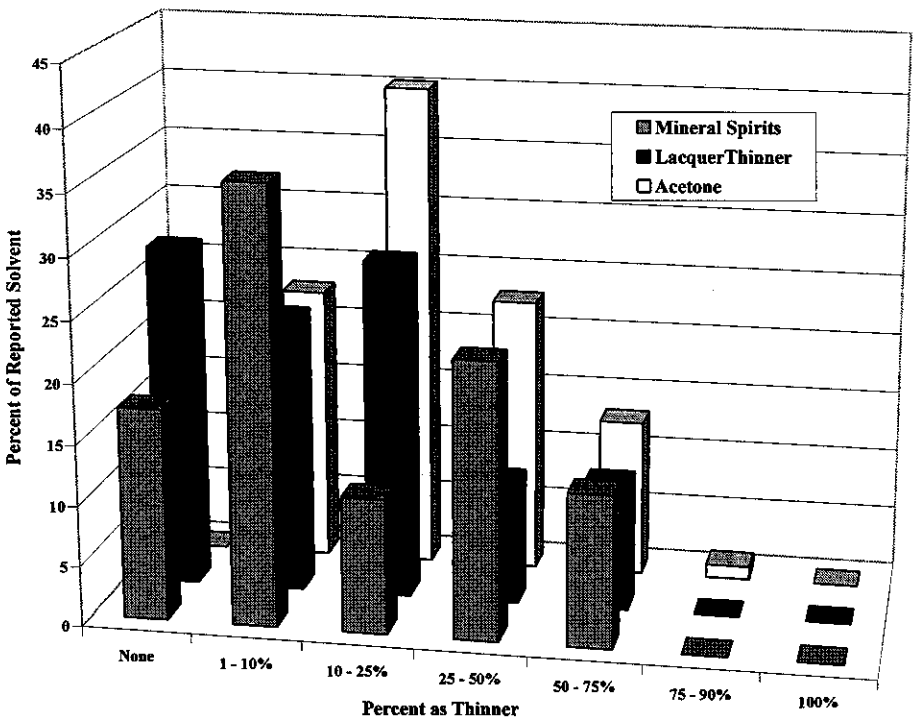

Figure 6-2. Percent of Total Solvent Used as Thinner: Mineral Spirits, Lacquer Thinner and Acetone.

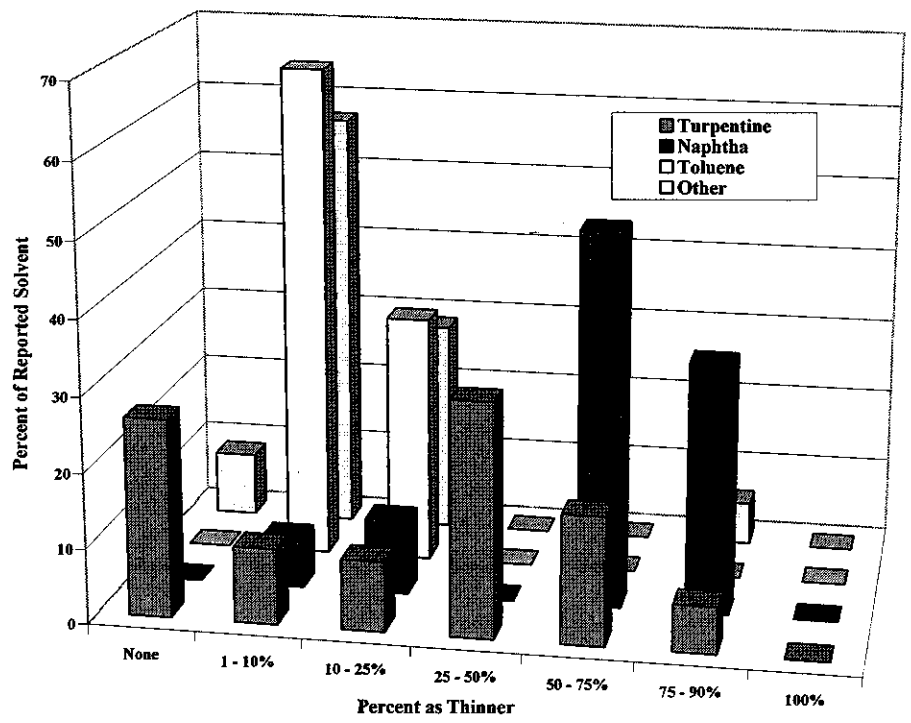

Figure 6-3. Percent of Total Solvent Used as Thinner: Turpentine, Naphtha, Toluene and "Other.".

cases, the ordinate is the percentage of total solvent use dedicated to a given thinner percent range.

For each solvent type, we calculated the weighted mean percentage devoted to thinning, using the reported solvent volumes as weights. For this calculation, we used the midpoint of each range; e.g., for "1 – 10%," we used 5.5. Figure 6-4 and Table 6-9 show the results. For all the solvent types except naphtha, less than half of the solvent reported was used as a thinner. For the most heavily used solvents (mineral spirits and lacquer thinner), thinner use constituted no more than about 20 percent of solvent use.

6.3.3 Projected Solvent Volumes

6.3.3.1 Statewide Volumes

We estimated statewide use of thinning and cleanup solvents (for solvent-based coatings) by multiplying the use of each type of solvent per household by the number of households in the State, which is 6,546,344 (U.S. Census, 2000). For use of solvents per household, we used the statewide averages shown in Tables 6-6 and 6-7, rather than averages for individual air basins. Although three basins had average use/household ratios that were significantly lower or higher than the corresponding statewide means for one or two solvent types,[36] we did not believe that using basin-specific averages would yield significant improvement in the accuracy of the statewide totals. The statewide total volume for each solvent type was apportioned between thinner and cleanup solvent use by the fractions shown in Table 6-9. Table 6-10 shows the results of these calculations. We estimate annual total thinning and cleanup solvent use by households to be 126,620 gallons per year.

6.3.3.2 Solvent Use by County

Table 6-11 shows the number of owner-occupied households in each county, according to the U.S. Census Bureau (U.S. Census, 2000). For each solvent type, statewide annual solvent use values from Table 6-10 were allocated to each county in proportion to that county's fraction of statewide households. Results are shown in Table 6-12.

[36] See Section 6.3.1.

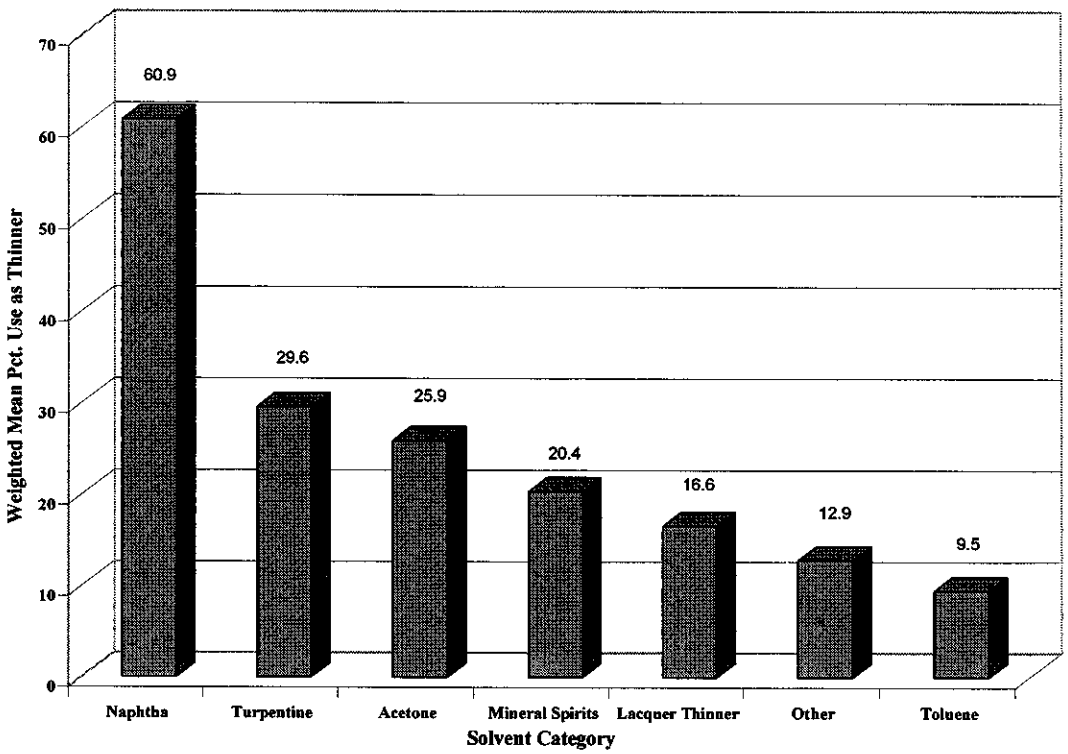

Figure 6-4. Weighted Percentages of Solvent Used as Thinner, by Solvent Type.

Table 6-9

WEIGHTED PERCENTAGES OF THINNER USE, BY SOLVENT TYPE

Solvent Type	Fraction of Total That is Used as Thinner
Mineral Spirits	0.2037
Lacquer Thinner	0.1662
Acetone	0.2590
Turpentine	0.2959
Naphtha	0.6087
Toluene	0.0950
Other	0.1286

Table 6-10

ESTIMATED ANNUAL USE OF THINNING AND CLEANUP SOLVENTS BY HOUSEHOLDS IN CALIFORNIA

Solvent Type	Weighted Mean Thinner Percent	Gallons Used per 5 Years Per Household	Statewide Solvent Use (Gallons per Year)		
			Thinner	Cleanup	Total
Mineral Spirits	20.37	0.02550	6,801	26,580	33,381
Lacquer Thinner	16.62	0.03399	7,396	37,112	44,508
Acetone	25.90	0.01133	3,843	10,993	14,836
Turpentine	29.59	0.01523	5,898	14,038	19,936
Naphtha	60.87	0.00390	3,104	1,996	5,100
Toluene	9.50	0.00071	88	839	927
Other	12.86	0.00578	974	6,599	7,572
Totals		0.09644	28,103	98,156	126,260

Table 6-11

OWNER OCCUPIED HOUSING UNITS, BY COUNTY

County	Housing Units	County	Housing Units
Alameda	286,277	Orange	574,456
Alpine	330	Placer	68,372
Amador	9,629	Plumas	6,301
Butte	48,336	Riverside	348,532
Calaveras	12,967	Sacramento	263,819
Colusa	3,853	San Benito	10,830
Contra Costa	238,449	San Bernardino	340,933
Del Norte	5,852	San Diego	551,461
El Dorado	44,019	San Francisco	115,391
Fresno	142,795	San Joaquin	109,667
Glenn	5,855	San Luis Obispo	57,001
Humboldt	29,534	San Mateo	156,133
Imperial	22,975	Santa Barbara	76,611
Inyo	5,076	Santa Clara	338,661
Kern	129,609	Santa Cruz	54,681
Kings	19,253	Shasta	41,910
Lake	16,914	Sierra	1,074
Lassen	6,575	Siskiyou	12,472
Los Angeles	1,499,744	Solano	84,994
Madera	23,934	Sonoma	110,475
Marin	64,024	Stanislaus	89,886
Mariposa	4,615	Sutter	16,632
Mendocino	20,383	Tehama	14,214
Merced	37,483	Trinity	3,981
Modoc	2,675	Tulare	67,913
Mono	3,084	Tuolumne	14,978
Monterey	66,213	Ventura	164,380
Napa	29,554	Yolo	31,506
Nevada	27,958	Yuba	11,105
Total			6,546,334

Table 6-12
(Part 1)
GAL/YR OF THINNERS AND CLEANUP SOLVENTS USED BY HOUSEHOLDS, BY SOLVENT TYPE AND COUNTY

County	Mineral Spirits	Lacquer Thinner	Acetone	Turpentine	County	Mineral Spirits	Lacquer Thinner	Acetone	Turpentine
Alameda	1,460	1,946	649	872	Orange	2,929	3,906	1,302	1,749
Alpine	2	2	1	1	Placer	349	465	155	208
Amador	49	65	22	29	Plumas	32	43	14	19
Butte	246	329	110	147	Riverside	1,777	2,370	790	1,061
Calaveras	66	88	29	39	Sacramento	1,345	1,794	598	803
Colusa	20	26	9	12	San Benito	55	74	25	33
Contra Costa	1,216	1,621	540	726	San Bernardino	1,738	2,318	773	1,038
Del Norte	30	40	13	18	San Diego	2,812	3,749	1,250	1,679
El Dorado	224	299	100	134	San Francisco	588	785	262	351
Fresno	728	971	324	435	San Joaquin	559	746	249	334
Glenn	30	40	13	18	San Luis Obispo	291	388	129	174
Humboldt	151	201	67	90	San Mateo	796	1,062	354	475
Imperial	117	156	52	70	Santa Barbara	391	521	174	233
Inyo	26	35	12	15	Santa Clara	1,727	2,303	768	1,031
Kern	661	881	294	395	Santa Cruz	279	372	124	167
Kings	98	131	44	59	Shasta	214	285	95	128
Lake	86	115	38	52	Sierra	5	7	2	3
Lassen	34	45	15	20	Siskiyou	64	85	28	38
Los Angeles	7,647	10,197	3,399	4,567	Solano	433	578	193	259
Madera	122	163	54	73	Sonoma	563	751	250	336
Marin	326	435	145	195	Stanislaus	458	611	204	274
Mariposa	24	31	10	14	Sutter	85	113	38	51
Mendocino	104	139	46	62	Tehama	72	97	32	43
Merced	191	255	85	114	Trinity	20	27	9	12
Modoc	14	18	6	8	Tulare	346	462	154	207
Mono	16	21	7	9	Tuolumne	76	102	34	46
Monterey	338	450	150	202	Ventura	838	1,118	373	501
Napa	151	201	67	90	Yolo	161	214	71	96
Nevada	143	190	63	85	Yuba	57	76	25	34
Totals						33,381	44,508	14,836	19,936

Table 6-12
(Part 2)
GAL/YR OF THINNERS AND CLEANUP SOLVENTS USED BY HOUSEHOLDS, BY SOLVENT TYPE AND COUNTY

County	Naphtha	Toluene	Other	County	Naphtha	Toluene	Other
Alameda	223	41	331	Orange	448	81	665
Alpine	0	0	0	Placer	53	10	79
Amador	8	1	11	Plumas	5	1	7
Butte	38	7	56	Riverside	272	49	403
Calaveras	10	2	15	Sacramento	206	37	305
Colusa	3	1	4	San Benito	8	2	13
Contra Costa	186	34	276	San Bernardino	266	48	394
Del Norte	5	1	7	San Diego	430	78	638
El Dorado	34	6	51	San Francisco	90	16	133
Fresno	111	20	165	San Joaquin	85	16	127
Glenn	5	1	7	San Luis Obispo	44	8	66
Humboldt	23	4	34	San Mateo	122	22	181
Imperial	18	3	27	Santa Barbara	60	11	89
Inyo	4	1	6	Santa Clara	264	48	392
Kern	101	18	150	Santa Cruz	43	8	63
Kings	15	3	22	Shasta	33	6	48
Lake	13	2	20	Sierra	1	0	1
Lassen	5	1	8	Siskiyou	10	2	14
Los Angeles	1,168	212	1,735	Solano	66	12	98
Madera	19	3	28	Sonoma	86	16	128
Marin	50	9	74	Stanislaus	70	13	104
Mariposa	4	1	5	Sutter	13	2	19
Mendocino	16	3	24	Tehama	11	2	16
Merced	29	5	43	Trinity	3	1	5
Modoc	2	0	3	Tulare	53	10	79
Mono	2	0	4	Tuolumne	12	2	17
Monterey	52	9	77	Ventura	128	23	190
Napa	23	4	34	Yolo	25	4	36
Nevada	22	4	32	Yuba	9	2	13
Totals					5,100	927	7,572

6.3.3.3 Solvent Use by Air Basin

We also used numbers of owner-occupied housing units to allocate statewide solvent use to air basins. The number of owner-occupied households in a given basin was assumed to equal the sum of the numbers of owner-occupied households for all the counties comprising each basin. However, eight counties (El Dorado, Kern, Los Angeles, Placer, Riverside, San Bernardino, Solano, and Sonoma) are in more than one air basin. We used county population values from *The 2003 California Almanac of Emissions and Air Quality* (Alexis et al., 2003) to apportion households from counties to basins. Let H_i be the number of households in County i. Suppose that parts of the county are in three basins, A, B, and C. Finally, let $P_{i,A}$, $P_{i,B}$, and $P_{i,C}$ be the portions of the county's population in the three basins. Then the county's contributions of households to the three basins are calculated as follows:

$$H_A = H_i P_{i,A}/(P_{i,A} + P_{i,B} + P_{i,C})$$

$$H_B = H_i P_{i,B}/(P_{i,A} + P_{i,B} + P_{i,C})$$

$$H_C = H_i P_{i,C}/(P_{i,A} + P_{i,B} + P_{i,C})$$

Table 6-13 shows the estimated number of owner-occupied households in each basin. Table 6-14 shows the estimated solvent consumption, by major solvent type, per air basin.

Table 6-13

OWNER-OCCUPIED HOUSEHOLDS, BY AIR BASIN

Air Basin	Owner-Occupied Households
Great Basin Valleys	8,490
Lake County	16,914
Lake Tahoe	12,933
Mojave Desert	150,637
Mountain Counties	118,030
North Central Coast	131,724
North Coast	73,417
Northeast Plateau	21,722
Sacramento Valley	522,275
Salton Sea	95,929
San Diego	551,461
SF Bay Area	1,384,196
San Joaquin Valley	598,572
South Central Coast	297,992
South Coast	2,562,041
Total	6,546,334

Table 6-14

ESTIMATED USE OF THINNING AND CLEANUP SOLVENTS BY HOUSEHOLDS, BY AIR BASIN

(Use in Gallons per Year)

Air Basin	Type of Thinning and Cleanup Solvent							
	Mineral Spirits	Lacquer Thinner	Acetone	Turpentine	Naphtha	Toluene	Other	Total
Great Basin Valleys	43	58	19	26	7	1	10	164
Lake County	86	115	38	52	13	2	20	326
Lake Tahoe	66	88	29	39	10	2	15	249
Mojave Desert	768	1,024	341	459	117	21	174	2,905
Mountain Counties	602	802	267	359	92	17	137	2,276
North Central Coast	672	896	299	401	103	19	152	2,541
North Coast	374	499	166	224	57	10	85	1,416
Northeast Plateau	111	148	49	66	17	3	25	419
Sacramento Valley	2,663	3,551	1,184	1,590	407	74	604	10,073
Salton Sea	489	652	217	292	75	14	111	1,850
San Diego	2,812	3,749	1,250	1,679	430	78	638	10,636
San Francisco Bay Area	7,058	9,411	3,137	4,215	1,078	196	1,601	26,697
San Joaquin Valley	3,052	4,070	1,357	1,823	466	85	692	11,545
South Central Coast	1,520	2,026	675	907	232	42	345	5,747
South Coast	13,064	17,419	5,806	7,802	1,996	363	2,964	49,414
Statewide	**33,381**	**44,508**	**14,836**	**19,936**	**5,100**	**927**	**7,572**	**126,260**

6.4 TEMPORAL PATTERNS

The following results are for homeowners who reported that they had painted in the past five years, using any type of coating.

6.4.1 Frequency of Painting

Homeowners were asked, "About how many times in the past five years have you done painting on your property?" Responses varied from one to fifteen.[37] Figure 6-5 shows the frequency distribution for all the responses. Almost two thirds of the respondents said that they had painted once in five years, and 95.5 percent had painted three or fewer times. The maximum reported frequency was 15 times.

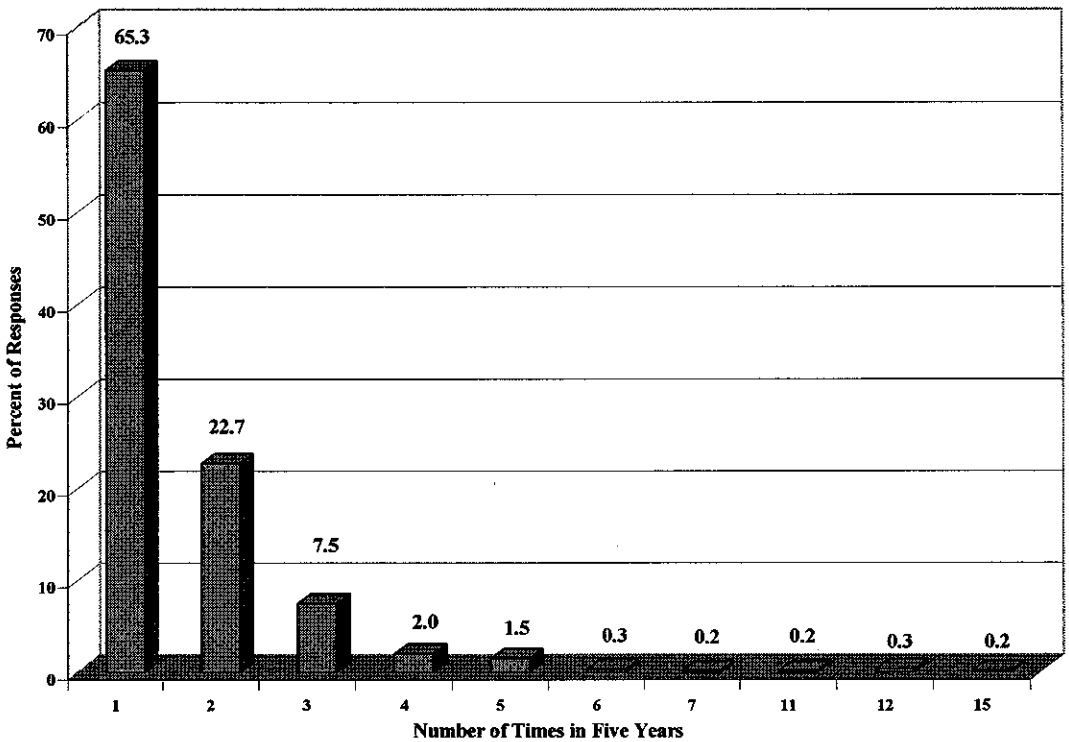

Figure 6-5. Reported Painting Frequency in the Last Five Years.

Table 6-15 shows the results of several statistical analyses of the painting frequency data by basin. The 90-percent confidence intervals for the mean number of times were calculated by the bootstrap sampling approach. For individual basins, reported frequencies that failed the Grubbs Test for Outliers were excluded from the data set; these values, however, were retained for the statewide calculations. For the State as a whole, the mean and median frequencies were 1.6 and 1 per five years, respectively. Only one air basin, the north coast, had a painting frequency that was significantly higher than the statewide mean. Except for that basin, the pooled results can be used to represent the state as a

[37] If they had not painted in the past five years, then the interview was ended.

Table 6-15

HOMEOWNER PAINTING FREQUENCY, BY AIR BASIN

Air Basin	n	Times Painted in Five Years			90-Percent Confidence Interval		Half CI/ Mean (%)
		Median	Mode	Mean	Low	High	
Great Basin Valleys	1	2	2	2.00	2.00	2.00	100.0
Lake County	4	1	1	1.50	1.00	2.00	33.3
Lake Tahoe							
Mojave Desert	18	1.5	1	1.61	1.39	1.83	13.8
Mountain Counties	9	2	1	1.67	1.33	2.00	20.0
North Central Coast	11	1	1	1.55	1.27	1.82	17.6
North Coast	8	2.5	3	2.50	2.00	3.13	22.5
Northeast Plateau	2	2	2	2.00	1.00	3.00	50.0
Sacramento Valley	73	1	1	1.44	1.32	1.56	8.6
Salton Sea	9	1	1	1.44	1.11	1.78	23.1
San Diego	48	1	1	1.56	1.40	1.73	10.7
SF Bay Area	140	1	1	1.47	1.39	1.56	5.6
San Joaquin Valley	45	1	1	1.49	1.29	1.71	14.2
South Central Coast	30	1	1	1.40	1.23	1.60	13.1
South Coast	203	1	1	1.56	1.48	1.65	5.5
Pooled[a,b]	**604**	**1**	**1**	**1.58**	**1.52**	**1.65**	**4.0**

[a]No responses received from households in the Lake Tahoe Air Basin.

[b]Includes four responses rejected as outliers for analyses of individual basins.

whole. The 90-percent confidence interval for times painted is {1.50, 1.66}; stated another way, the average homeowner paints his or her house every 3.0 to 3.3 years.

6.4.2 Seasonal Variation

Respondents were asked what was the season of the year in which they last painted their houses. The intention was to obtain one data point (i.e. one season) for each respondent. Unfortunately, some respondents reported more than one season for their previous painting activity. Rather than arbitrarily discard these data, we calculated the fraction of each household painting activity that occurred in each season. In most cases, this value was "1," and was assigned to the single season reported. Let n be the number of seasons reported by a household. For those reporting more than one season, the fraction of activity in the ith season, F_i, was defined as:

F_i = 1/n; for a season in which painting was reported

= 0; for a season in which no painting was reported

The values for F_i were 0, 0.25, 0.333, 0.5, and 1. The seasonal fractions were averaged for all the households in each air basin, for each season. Confidence intervals about the mean were determined by bootstrap sampling.

Table 6-16 summarizes the results by air basin. If painting were equally likely in all seasons of the year, then the mean seasonal fraction would be 0.25. This is not the case, however. For many air basins, and for the state as a whole, significantly more painting takes place in the spring and summer than in the fall and winter. Figure 6-6 shows the statewide distribution of activity, and Table 6-17 lists air basins in which activity is significantly different from uniform.

6.4.3 Weekday Versus Weekend

Homeowners were asked whether, the last time they painted, they painted only during the week, only on a weekend, or on both weekdays and weekends. Figures 6-7, 6-8 and 6-9 show the percentages of each air basin's respondents who gave the three answers, respectively. In most of the air basins, at least 50 percent of the respondents painted only during the week. The lowest percentage of weekday painters was in Lake County (25 percent). Except for Lake County, fewer than half the households in all the air basins reported painting only on weekends.

Figure 6-10 summarizes the combined responses for all the air basins. A little more than half the reporting households painted on weekdays only. About 28 percent painted on weekends only, and the rest divided their painting activity between the week and the weekend.

6.4.4 Diurnal Patterns

Homeowners were asked to report the time(s) of day in which they last painted, in any combination of the following six-hour intervals:

- Midnight to 6 a.m.
- 6 a.m. to noon
- Noon to 6 p.m.
- 6 p.m. to midnight

For each household, we calculated the fraction of time spent in each six-hour interval. For example, if the homeowner painted from 6 a.m. to noon and from noon to 6 p.m., then each of those two time intervals received a "score" of 0.5. The "scores" were averaged over all the households, for each time interval, in each air basin.

Table 6-16

DISTRIBUTION OF HOMEOWNER PAINTING ACTIVITY BY SEASON, FOR EACH AIR BASIN

Air Basin	n	Spring			Summer			Fall			Winter		
		Mean	90% Conf. Interval		Mean	90% Conf. Interval		Mean	90% Conf. Interval		Mean	90% Conf. Interval	
			Low	High		Low	High		Low	High		Low	High
Great Basin Valleys	1	**0.000**	N/A	N/A	**0.000**	N/A	N/A	**0.500**	N/A	N/A	**0.500**	N/A	N/A
Lake County	4	**0.000**	0.000	0.000	**0.375**	0.125	0.625	**0.625**	0.375	0.875	**0.000**	0.000	0.000
Lake Tahoe													
Mojave Desert	19	**0.342**	0.211	0.474	**0.342**	0.211	0.474	**0.184**	0.079	0.289	**0.132**	0.053	0.237
Mountain Counties	8	**0.313**	0.125	0.500	**0.250**	0.000	0.500	**0.250**	0.000	0.500	**0.188**	0.000	0.375
North Central Coast	11	**0.273**	0.136	0.409	**0.545**	0.364	0.727	**0.136**	0.000	0.273	**0.045**	0.000	0.091
North Coast	8	**0.125**	0.000	0.250	**0.417**	0.208	0.625	**0.292**	0.125	0.458	**0.167**	0.063	0.271
Northeast Plateau	3	**0.500**	0.167	0.833	**0.167**	0.000	0.333	**0.167**	0.000	0.333	**0.167**	0.000	0.333
Sacramento Valley	69	**0.384**	0.312	0.457	**0.266**	0.203	0.331	**0.287**	0.220	0.355	**0.063**	0.029	0.099
Salton Sea	8	**0.250**	0.125	0.500	**0.250**	0.125	0.500	**0.250**	0.125	0.500	**0.250**	0.125	0.500
San Diego	46	**0.339**	0.261	0.420	**0.350**	0.266	0.433	**0.154**	0.094	0.217	**0.158**	0.092	0.223
SF Bay Area	136	**0.298**	0.252	0.346	**0.276**	0.230	0.322	**0.272**	0.228	0.318	**0.154**	0.191	0.200
San Joaquin Valley	45	**0.439**	0.344	0.533	**0.228**	0.150	0.311	**0.172**	0.106	0.244	**0.161**	0.089	0.233
South Central Coast	30	**0.242**	0.158	0.333	**0.342**	0.233	0.450	**0.242**	0.150	0.333	**0.175**	0.100	0.258
South Coast	191	**0.380**	0.337	0.422	**0.316**	0.276	0.356	**0.199**	0.165	0.236	**0.104**	0.078	0.131
Pooled[a]	**579**	**0.343**	0.320	0.366	**0.302**	0.279	0.324	**0.228**	0.206	0.249	**0.128**	0.111	0.144

[a]No responses received from households in the Lake Tahoe Air Basin.

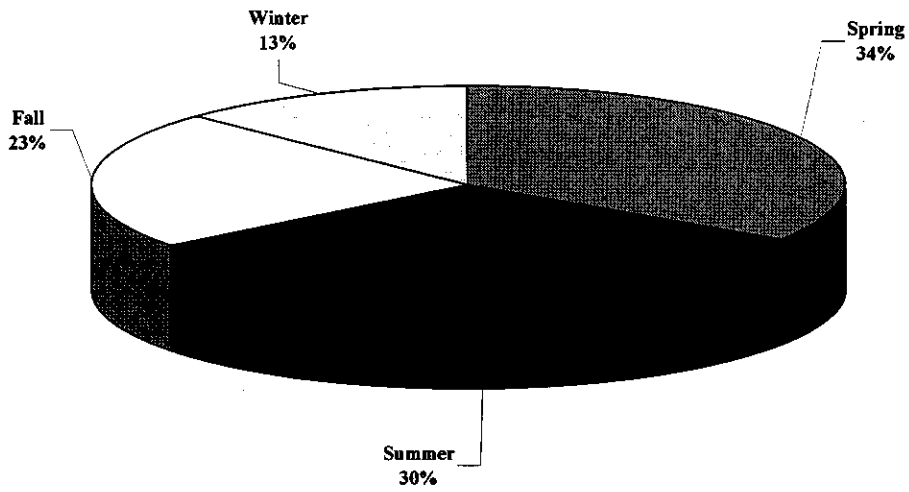

Figure 6-6. Distribution of Statewide Homeowner Painting Activity, by Season.

Table 6-17

SEASONS WITH HIGHER OR LOWER ACTIVITY, BY BASIN

Activity	Spring	Summer	Fall	Winter
Significantly Higher	Sacramento Valley San Diego San Francisco Bay Area San Joaquin Valley South Coast	North Central Coast San Diego South Coast	None	None
Significantly Lower	None	None	San Diego San Joaquin Valley South Coast	Mojave Desert North Central Coast Sacramento Valley San Diego San Francisco Bay Area

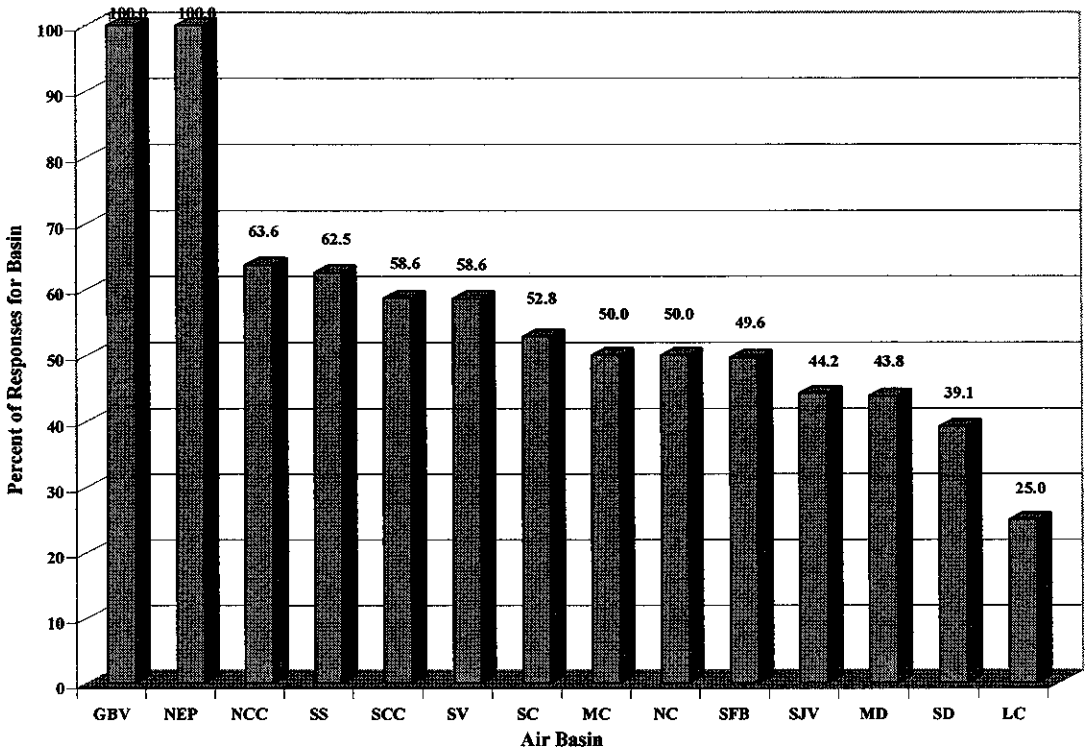

Figure 6-7. Percentage of Households in Each Basin Who Painted Only on Weekdays.

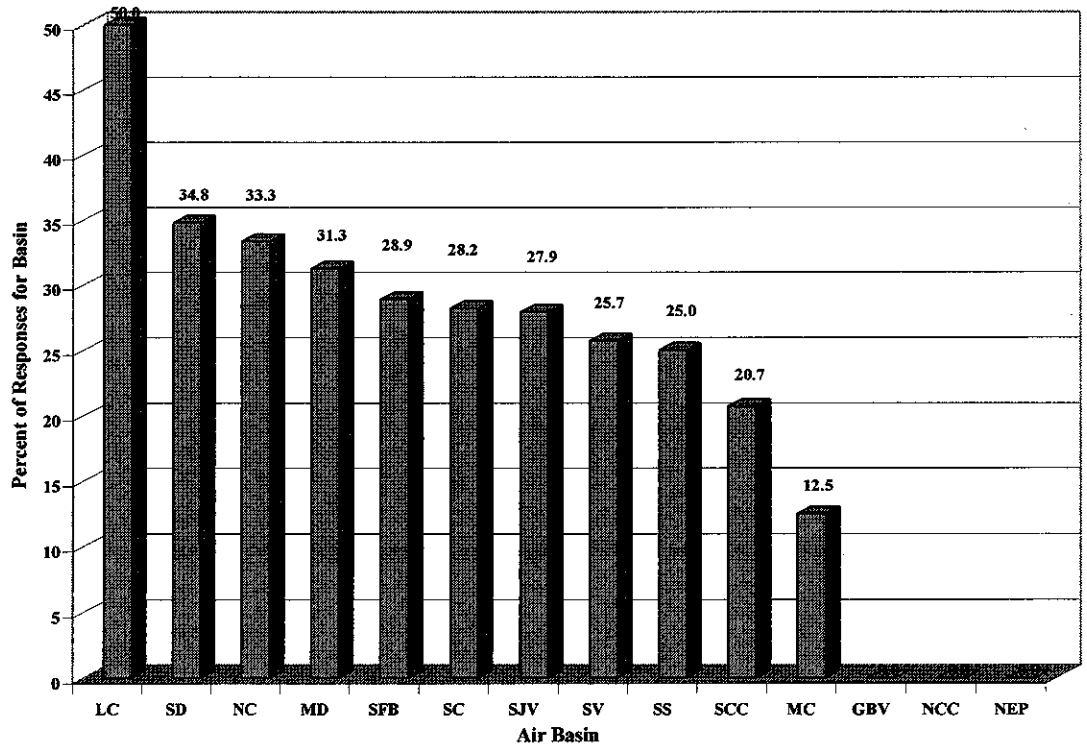

Figure 6-8. Percentage of Households in Each Basin Who Painted Only on Weekends.

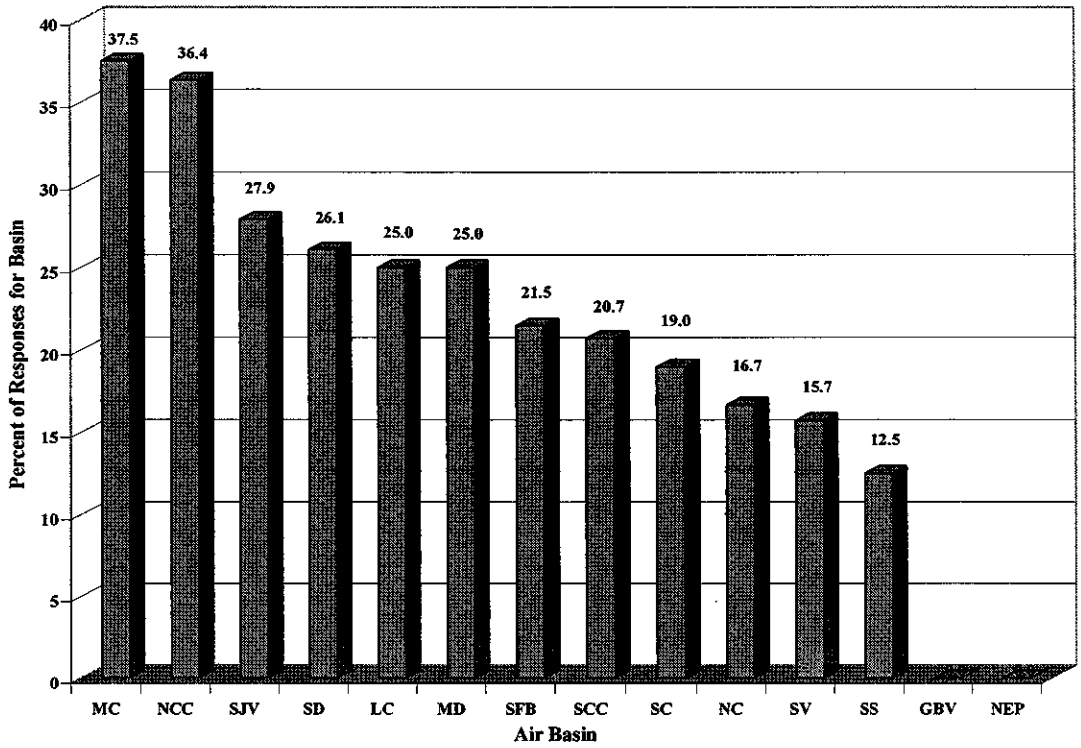

Figure 6-9. Percentage of Households in Each Basin Who Painted on Weekdays and Weekends.

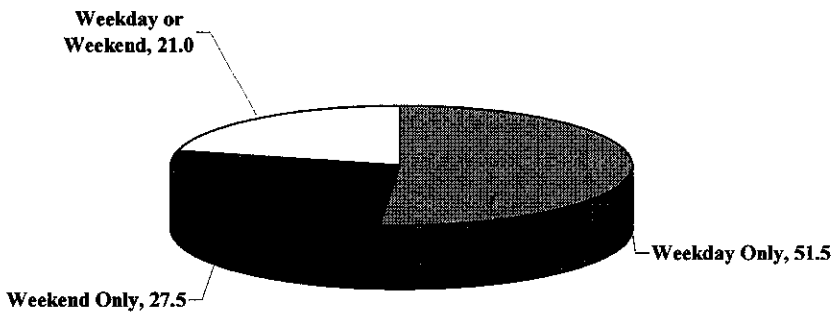

Figure 6-10. Percentage of California Households Who Painted on Weekdays, Weekends, or Both.

Table 6-18 summarizes the results of the calculations, by air basin and for the State. As would be expected, from 85 to 100 percent of the painting activity is from 6 a.m. to 6 p.m. In all the basins for which there was more than one response, more homeowners, on the average, painted in the morning than did in the afternoon. The difference in mean activity fraction (morning vs. afternoon) was significant (at the 90-percent confidence level) for the North Coast, Northeast Plateau, Sacramento Valley, San Diego, San Francisco, San Joaquin Valley, South Central Coast, and South Coast Air Basins, and for the state as a whole.

6.5 WEATHER EFFECTS

Homeowners were asked what their response to different weather conditions would be on the *next* time that they painted. For very hot, very cold or inclement weather, they were given the following choices:

- Not paint at all
- Paint only indoors
- Paint earlier in the day than you would if the weather were not extreme
- Paint later in the day than you would if the weather were not extreme
- No effect on painting activity

Note that more than one choice was allowed, as long as the choices were not mutually exclusive. For example, on a hot day, a person could paint earlier and later than usual. However, the choices could not be "paint earlier" and "not paint at all."

Since it is the most drastic response, we first looked at the responses for "not paint at all." For each basin, we calculated the proportion of respondents who gave this response, for each weather condition. The results are shown in Table 6-19. Roughly the same proportion of households (about 40 to 42 percent) would not paint if the weather were extremely hot or extremely cold. The proportion of homeowners that would not paint in inclement weather is significantly higher (at the 90-percent confidence level) than the proportion that would not paint in extremely hot or cold weather, for the State as a whole and for five air basins (North Coast, Sacramento Valley, San Francisco Bay Area, South Central Coast, and South Coast).

For the no-painting response, there is not much difference among air basins. San Diego and Lake County are the only ones where the proportion who would not paint in hot weather is significantly higher than for the State as a whole. For cold weather, only the proportion for the Mojave Desert Air Basin is significantly lower, and the proportion for the South Coast Air Basin is higher, than for the State as a whole. For inclement weather, only the respondents in the Mountain Counties Air Basin would be more willing, and the respondents in the North Coast and South Coast Air Basins would be less willing, to paint than would the State as a whole.

Table 6-18

FRACTIONS OF TIMES PAINTED IN EACH 6-HOUR INTERVAL, BY BASIN

Air Basin	n	Midnight - 6 a.m.			6 a.m. - Noon			Noon - 6 p.m.			6 p.m. - Midnight		
		Mean	90% Conf. Interval		Mean	90% Conf. Interval		Mean	90% Conf. Interval		Mean	90% Conf. Interval	
			Low	High		Low	High		Low	High		Low	High
Great Basin Valleys	1	**0.000**	N/A	N/A	**0.000**	N/A	N/A	**1.000**	N/A	N/A	**0.000**	N/A	N/A
Lake County	4	**0.000**	0.000	0.000	**1.000**	1.000	1.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000
Lake Tahoe[a]													
Mojave Desert	19	**0.000**	0.000	0.000	**0.500**	0.377	0.623	**0.395**	0.272	0.518	**0.105**	0.035	0.175
Mountain Counties	9	**0.000**	0.000	0.000	**0.537**	0.426	0.667	**0.426**	0.315	0.556	**0.037**	0.000	0.074
North Central Coast	10	**0.000**	0.000	0.000	**0.433**	0.300	0.567	**0.433**	0.300	0.567	**0.133**	0.067	0.200
North Coast	8	**0.000**	0.000	0.000	**0.646**	0.479	0.813	**0.271**	0.125	0.417	**0.083**	0.000	0.167
Northeast Plateau	3	**0.000**	0.000	0.000	**0.833**	0.667	1.000	**0.167**	0.000	0.333	**0.000**	0.000	0.000
Sacramento Valley	69	**0.000**	0.000	0.000	**0.582**	0.517	0.647	**0.379**	0.316	0.442	**0.039**	0.024	0.053
Salton Sea	9	**0.111**	0.000	0.222	**0.481**	0.315	0.667	**0.370**	0.204	0.556	**0.037**	0.000	0.074
San Diego	48	**0.021**	0.000	0.042	**0.556**	0.486	0.625	**0.368**	0.302	0.434	**0.056**	0.035	0.076
SF Bay Area	140	**0.006**	0.000	0.012	**0.562**	0.520	0.603	**0.337**	0.298	0.376	**0.095**	0.074	0.118
San Joaquin Valley	44	**0.017**	0.000	0.034	**0.532**	0.458	0.606	**0.350**	0.286	0.417	**0.100**	0.064	0.140
South Central Coast	29	**0.000**	0.000	0.000	**0.563**	0.471	0.655	**0.305**	0.236	0.379	**0.132**	0.080	0.190
South Coast	200	**0.000**	0.000	0.000	**0.591**	0.556	0.626	**0.343**	0.311	0.377	**0.066**	0.050	0.083
Pooled	**593**	**0.006**	0.003	0.010	**0.572**	0.552	0.592	**0.347**	0.327	0.366	**0.075**	0.066	0.085

[a]No responses received from households in the Lake Tahoe Air Basin.

Table 6-19

PROPORTIONS OF OWNER-OCCUPIED HOUSEHOLDS WHO WOULD NOT PAINT IN EXTREME WEATHER CONDITIONS, BY BASIN

Air Basin	n	Hot Weather			Cold Weather			Inclement Weather		
		Mean	90% Conf. Interval		Mean	90% Conf. Interval		Mean	90% Conf. Interval	
			Low	High		Low	High		Low	High
Great Basin Valleys	1	**1.000**	0.000	0.000	**0.000**	0.000	0.000	**1.000**	0.000	0.000
Lake County	4	**0.750**	0.500	1.000	**0.500**	0.250	0.750	**0.750**	0.500	1.000
Lake Tahoe[a]										
Mojave Desert	19	**0.263**	0.158	0.421	**0.263**	0.158	0.368	**0.474**	0.316	0.632
Mountain Counties	9	**0.333**	0.111	0.556	**0.222**	0.000	0.444	**0.333**	0.111	0.556
North Central Coast	11	**0.364**	0.182	0.545	**0.545**	0.364	0.727	**0.727**	0.545	0.909
North Coast	8	**0.250**	0.125	0.500	**0.500**	0.250	0.750	**0.875**	0.750	1.000
Northeast Plateau	3	**0.000**	0.000	0.000	**0.333**	0.000	0.667	**0.667**	0.333	1.000
Sacramento Valley	73	**0.356**	0.288	0.425	**0.342**	0.274	0.411	**0.534**	0.452	0.603
Salton Sea	9	**0.333**	0.111	0.556	**0.333**	0.111	0.556	**0.556**	0.333	0.778
San Diego	49	**0.551**	0.469	0.633	**0.367**	0.286	0.449	**0.633**	0.551	0.714
SF Bay Area	142	**0.408**	0.359	0.458	**0.366**	0.310	0.423	**0.599**	0.542	0.648
San Joaquin Valley	45	**0.467**	0.378	0.556	**0.400**	0.311	0.489	**0.578**	0.489	0.667
South Central Coast	31	**0.355**	0.258	0.452	**0.355**	0.258	0.452	**0.581**	0.452	0.677
South Coast	202	**0.450**	0.406	0.495	**0.480**	0.436	0.525	**0.733**	0.693	0.772
Pooled	**606**	**0.421**	0.396	0.446	**0.401**	0.376	0.427	**0.635**	0.611	0.660

[a]No responses received from households in the Lake Tahoe Air Basin.

Table 6-20 shows the distributions of all the responses, by type of extreme weather and air basin. For most air basins, the option of painting only indoors was reported by higher proportions of respondents for the case of inclement weather than for hot or cold weather. Also for most basins, the option of painting earlier in the day is reported more for the case of hot weather than for those of cold or inclement weather.

Table 6-20

PERCENTAGES OF HOMEOWNERS CHOOSING EACH OPTION FOR HOT, COLD AND INCLEMENT WEATHER, BY BASIN

Air Basin	Hot Weather					Cold Weather					Inclement Weather				
	No Painting	Indoor Only	Earlier	Later	No Effect	No Painting	Indoor Only	Earlier	Later	No Effect	No Painting	Indoor Only	Earlier	Later	No Effect
Great Basin Valleys	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Lake County	75.0	0.0	25.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	75.0	25.0	0.0	0.0	0.0
Lake Tahoe[a]															
Mojave Desert	26.3	21.1	26.3	10.5	15.8	26.3	31.6	10.5	5.3	36.8	47.4	47.4	0.0	0.0	5.3
Mountain Counties	33.3	0.0	11.1	0.0	55.6	22.2	33.3	0.0	0.0	44.4	33.3	44.4	0.0	0.0	22.2
North Central Coast	36.4	9.1	18.2	9.1	36.4	54.5	18.2	0.0	0.0	27.3	72.7	18.2	0.0	0.0	0.0
North Coast	25.0	25.0	50.0	25.0	0.0	50.0	50.0	0.0	0.0	0.0	87.5	0.0	0.0	0.0	0.0
Northeast Plateau	0.0	33.3	0.0	0.0	66.7	33.3	33.3	0.0	0.0	33.3	66.7	33.3	0.0	0.0	0.0
Sacramento Valley	35.6	13.7	13.7	4.1	34.2	32.9	26.0	13.7	5.5	28.8	53.4	39.7	0.0	0.0	6.8
Salton Sea	33.3	11.1	22.2	11.1	22.2	33.3	11.1	11.1	0.0	44.4	55.6	22.2	0.0	0.0	22.2
San Diego	55.1	10.2	24.5	12.2	8.2	36.7	32.7	14.3	14.3	16.3	63.3	28.6	2.0	0.0	4.1
SF Bay Area	40.8	7.0	21.1	11.3	28.9	36.6	26.1	7.7	5.6	28.2	59.9	30.3	2.8	1.4	7.7
San Joaquin Valley	46.7	11.1	17.8	4.4	20.0	40.0	28.9	2.2	6.7	22.2	57.8	31.1	2.2	2.2	6.7
South Central Coast	35.5	12.9	16.1	12.9	32.3	35.5	16.1	9.7	6.5	35.5	58.1	41.9	0.0	0.0	0.0
South Coast	45.0	7.4	20.3	7.4	22.3	48.0	16.8	5.4	5.9	27.2	73.3	17.8	0.5	0.5	7.4
Pooled	42.1	9.6	20.0	8.6	24.8	40.1	23.8	7.6	6.1	27.1	63.5	27.7	1.2	0.7	6.8

[a]No responses received from households in the Lake Tahoe Air Basin.